FOREST PRODUCTS RESEARCH 1952

DEPARTMENT OF SCIENTIFIC
AND INDUSTRIAL RESEARCH

THREE SHILLINGS NET

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

REPORT OF THE FOREST PRODUCTS RESEARCH BOARD

WITH THE REPORT OF
THE DIRECTOR OF FOREST PRODUCTS RESEARCH

FOR THE YEAR
1952

LONDON: HER MAJESTY'S STATIONERY OFFICE
1953

FOREST PRODUCTS RESEARCH BOARD

1952

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	Ministry of Works ..	W. Abnett, Esq.

[1] Until 31st March, 1952.
[2] From 1st April, 1952.

Department of Scientific and Industrial Research,
Charles House, 5-11 Regent Street,
London, S.W.1.

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REPORT OF THE FOREST PRODUCTS RESEARCH BOARD FOR THE YEAR 1952

To the Lords of the Committee of the Privy Council for Scientific and Industrial Research

MAY IT PLEASE YOUR LORDSHIPS,

WE, the Forest Products Research Board, beg leave to present our report for the year ending 31st December, 1952.

The testing and evaluation of new tropical species, mainly Colonial, continues to be the Laboratory's major project, but it is to be expected that the work which began this year on the assessment of home-grown softwoods from various forest sites of the Forestry Commission will increase in proportion during the coming and successive years. These programmes of timber testing together with advisory work continue to occupy much of the available staff time.

Using as a measure the number of routine enquiries answered by leaflet (52,300) and the number of specialized enquiries dealt with by letter or report (6,300), the demand for advisory service this year has, after remaining steady for the three previous years, again increased and a corresponding diversion of effort has been required to deal with it. Nevertheless, we are pleased to report that during the year there was a further increase in the amount of the more basic and long-term types of work being carried on. Also in spite of the heavy programmes in their own specialist sections, officers have found time to increase the number of projects which involve inter-sectional collaboration. For example, the project upon the permanent effect of temperature on the strength of wood, and that upon the preservation of plywood.

The demand for lectures and visits, particularly by industrial bodies, is still greater than can be dealt with and the constant difficulty is present of deciding how much of senior officers' time can be allocated to such direct means of spreading knowledge of the Laboratory's work where it is most needed. In addition to these channels of general propaganda, and those of the press, exhibitions and broadcasting, the major task of disseminating directly the results of the work is carried on by individual contact both at the Laboratory and outside, and by specific visits to firms in the wood-using industries. Day to day work, although it absorbs much of the time available, is dealt with in the Director's report and does not call for comment here. There are, however, various aspects of particular interest to which we would invite attention:

TROPICAL TIMBERS

In many industries tropical timbers are being used in place of the traditional species; indeed, the increase in the use of these timbers as compared with their pre-war use has been greater in this country than in any other in Western Europe. This increased use is reflected in the great volume of enquiries on the identification and properties of unfamiliar species received by the Laboratory. The leaflets

on new timbers, published on the completion of their testing, provide routine answers to many of the enquiries. Pending the publication of the leaflets, interim information is furnished to enquirers from the Laboratory's sectional records.

IDENTIFICATION OF TIMBERS

The Lens Key to the Identification of Hardwoods was published during the year, and a companion atlas of low-power photomicrographs is in course of preparation. Using the assembly of perforated cards prepared from the Lens Key and with the atlas as a check, an investigator, even although he lacks access to a standard collection of timbers, will be able to identify any of the four hundred timbers which are dealt with in the Key, and which include all species, home-grown or exotic, which are likely to be encountered in this country at the present time.

SEASONING PROBLEMS

Among the more interesting of the short-term trials are those on the seasoning of birch for brushes, and on the kiln-drying of East African pencil slats. An investigation of longer-term importance is that upon the factors which affect the shrinkage of wood during drying. So far curves have been obtained for beech cut transversely and tangentially and dried slowly or quickly at six different temperatures. The results are being used to interpret general findings in practical kiln-drying.

WOOD BENDING

The new bending laboratory was occupied and all the machines installed early in the year. An addition to the programme is a project to devise suitable techniques for making laminated bends of large cross-section for use in boat-building. Further development is also proceeding on the Laboratory's patented process for making plywood corners of small radius.

TIMBER MECHANICS

In the kiln-drying of wood, tension stresses set up across the fibres are of special significance as the major seasoning defects induced by uneven drying are associated with such tensions. A knowledge of the permanent effect of temperatures in the seasoning range, i.e. up to 70°C (as distinct from any temporary effects) on the strength and elasticity of timber is required for the solution of fundamental seasoning problems. A series of experiments has therefore been begun to study the effect of high temperatures on strength properties.

Work on the three elements of the programme on timber structures—the individual wooden structure members, the joints and the complete structures—was continued and extended. New projects on the strength of struts and of nailed joints were started, and a paper published embodying the results of past and recent work on joints made with shear connectors.

PLYWOOD INVESTIGATIONS

Several of the long-term durability tests in which plywood and assembly adhesives have been subjected to full weathering and semi-outdoor exposure have passed their fifth year. The results of these tests have been analysed, and

a new series of weathering tests has been devised in which the more recent adhesives and improved methods of testing will be used. As a result of continued collaboration with the plywood manufacturers and of further experience in the assessment of yields at different stages in manufacture, the Manual of 1950, which describes the scheme of tests, has been revised and re-issued. A simple classification of species for their suitability for plywood manufacture has been made.

As in previous years, the relevant plywood research projects and their progress were under constant survey and discussion by the informal industrial panels—the Adhesive Makers' Panel and the Plywood Research Panel—to whose members our thanks are again accorded.

PRESERVATIVE TREATMENT OF PLYWOOD

The durability of some of the modern plywood adhesives is so great that they outlast the wood, which is now the component of the assembly which deteriorates first in service. Priority was given to the production of preservation-treated plywood, and the practical methods of manufacture either by preservation of its component veneers or by impregnation of the finished plywood are being actively investigated.

THE 'SOFT ROT' FUNGI

The recognition of an unusual type of decay in water-cooling towers mentioned in our last report has led to a major and very interesting investigation into the physiology of the group of Ascomycete fungi which cause the decay. In addition to collaborative work with the British Electricity Authority on practical problems raised, tests were made to assess the suitability of hardwoods as fillings for the water-towers in place of the traditional softwoods. At the same time basic studies were carried out on the effect of temperature on the rate of growth, and on the nutrition of these fungi, and on comparison of their virulence of attack with that of other types of wood-destroying fungi. Awareness of the type of decay caused by these Ascomycetes has led to its recognition in many other sites.

DECAY OF TIMBER IN BOATS

The widespread incidence of decay in boats disclosed in the Laboratory's advisory work led to the holding of a meeting early in the year of representatives of all those interested in small timber-built craft. As a result, the Laboratory is to publish a bulletin and a leaflet for the guidance of naval architects, boat-builders and others interested, and is engaged in a survey to gauge the magnitude of the problems and the best means of solving them. The cognate problem of corrosion of metals in contact with boat timbers is being studied concurrently, and we would draw your Lordships' attention to a short account of electro-chemical attack on boat timbers which appears on page 42 of the Director's report.

ENTOMOLOGICAL WORK

Studies on the biology of all the important wood-destroying insects were continued, but the common furniture beetle and the house longhorn beetle were given particular attention because of their immediate importance. With the

furniture beetle the effect of progressive decay in the wood on the development of the larvae was confirmed, and further work is in hand upon the effect of moisture content and fluctuating conditions of temperature and humidity on the rate of growth of its larvae. The effect of removal of extractives from the sapwood upon its susceptibility to attack is also being investigated.

Survey of damage by the house longhorn beetle in new localities of infestation in co-operation with a local authority, and the recording of temperatures and humidities in the roofs of buildings in areas already infested were continued during the year. In the laboratory, studies continued on the behaviour of the beetles, their emergence, egg-laying and length of life under different conditions. Work on their nutrition is also in hand.

INSECT DAMAGE IN IMPORTED TIMBERS

Because of the extensive damage to imported tropical timbers by ambrosia beetles (pinhole borers) the Laboratory submitted to the Colonial Research Council a memorandum outlining the problems involved and outlining a programme of research. This was approved by the Governments of the Gold Coast and Nigeria and led to the appointment of a team of three biologists as a West African Timber Insect Research Unit. The Laboratory has undertaken the specialized training of the team, two of whom will later proceed to West Africa, the third remaining at Princes Risborough. The results of sporadic experiments in the tropics on the means of preventing the present serious damage to commercial timbers have already shown that an increase of knowledge of the biology of the insects should result in their effective control. The formation of the new biological unit to study the specific problem is therefore very gratifying.

WOOD ANALYSIS

The work on the delignification of wood by sodium chlorite solution, leading to the discovery and isolation of an acid-soluble form of lignin in wood has now been published. A further paper describes the preparation of a fairly pure hemicellulose fraction from beech wood. The isolation and purification of the remaining hemicelluloses and an examination by partition chromatography of the sugars formed by hydrolysis of the various polysaccharide fractions of the wood cell wall will now be attempted.

FIBREBOARDS FROM COLONIAL TIMBERS

In our report of 1951 we were able to state that fibreboards of good quality had been made from the British Guiana wood, wallaba, and the procedure was described in the Director's report for that year. Boards having the same very satisfactory strength properties have now been prepared from the wood of another British Guiana timber, morabukea, using a similar technique. The water-absorption of the boards from both timbers is high, and those made from wallaba from which the gum has been extracted in the course of its integrated utilization scheme have considerably higher water absorption than those from the unextracted wood. Attention was therefore turned to improving the water-resistance of the boards without significant loss of strength, and this has been done by the use of rosin size or of wax emulsions. Boards treated this way satisfy the British Standard Specification both as to strength and water obsorption. Cost of manufacture will also be a determining factor in the successful production of hardboards made from tropical woods. Experiments are now

in progress to determine the practical lower limit of chemical consumption for making boards to meet the specification, and also to lower the consumption of chemicals by more efficient defibering of the cooked chips.

MEMBERSHIP OF THE BOARD

On the completion of his term of office, Sir Edward Salisbury retired from the Board in March, 1952. We wish to put on record our thanks to Sir Edward and our appreciation of his services to the Laboratory and to the Board during the period of his office as Chairman.

H.R.H. THE DUKE OF EDINBURGH

We wish to record with pleasure that on 30th April, 1952, the Laboratory was honoured by a visit by H.R.H. The Duke of Edinburgh, who spent the whole day inspecting the work going on in the various sections and workshops.

R. G. BENNETT,
Chairman.

February, 1953.

REPORT OF THE DIRECTOR OF FOREST PRODUCTS RESEARCH FOR THE YEAR 1952

INTRODUCTION

During the year 1952 there has been little change in the nature and orientation of the Laboratory's work apart from minor adjustments of programme required by contemporary circumstances. The testing and evaluation of new timbers, mostly from the Colonies, and the dissemination of information about them are still the main project in the programme and, together with the heavy demand for industrial advisory work, still take up a large part of the available time. There has been no change in the permitted complement of staff, and basic research has therefore, as in previous years, been limited by the amount of time remaining after these other commitments have been met. Nevertheless, it is gratifying to record that there has again been an increase in research work, not only of the more fundamental kind, but also in technical projects of the broader sort which can lead to practical generalization. There has also been a noticeable increase in the amount of collaborative work involving several sections and this, in an establishment necessarily heavily specialized, is a healthy sign.

Our relations with outside bodies and institutions, with private firms, other government departments and the general public remain excellent. Our close liaison with the service departments has been maintained, largely through their assessors on the Research Board, and collaboration with the Forestry Commission increases, particularly in the project for evaluation of home-grown softwoods from their plantations on various sites. Through its representation on committees such as the research committee of the Furniture Development Council, the National Education Committee of the Timber Development Association, and numerous committees of the British Standards Institution the Laboratory continues to place its experience and advice at the disposal of those who desire them.

GENERAL

VISIT OF H.R.H. THE DUKE OF EDINBURGH

On 30th April, 1952, the Laboratory was honoured by a visit of H.R.H. the Duke of Edinburgh, during which he spent the whole day inspecting the various sections and workshops. The visit was an informal one, and His Royal Highness saw the everyday work of the Laboratory in progress. He took a keen and penetrating interest in the different projects and was kind enough to say that he had passed an enjoyable day. During the visit he suggested that an inspection should be made of the sailing ship "*Cutty Sark*", in which he is interested. A full inspection was made and is referred to on pages 33 and 44 of this Report. At his request, also, the agent from Sandringham Estate, Captain Fellowes, and the Estate Forester visited the Laboratory at a later date to see the work in hand.

STAFF, BUILDINGS AND EQUIPMENT

The structure and proportions of the complement remain essentially the same as in 1951.

The new Wood Bending Laboratory was completed and staff and equipment were moved in during the early part of the year. A view of the main workroom is shown in Plate 1.

TOURS ABROAD

The Director and Mr. J. Bryan attended the 6th British Commonwealth Forestry Conference at Ottawa in the early autumn. Between 4th and 13th August they took part in the pre-Conference meeting of the Forest Products section, and also in the opening sessions of the Main Conference, and then went on the Conference's tour of visits to places of technical interest as guests of the Quebec provincial government. The Director then took the opportunity of visiting the Forest Products Laboratory at Madison, Wisconsin, and industrial plants in Wisconsin and Ontario, while Mr. Bryan completed the Conference tour in Ontario, returning home on 5th September. The Director rejoined the party for the latter part of the Ontario tour and attended the remaining sessions of the Forestry Conference in Ottawa, and thereafter visited projects of interest in Saskatchewan, Alberta and British Columbia, returning home on 17th October. The whole trip was most successful. This was due not only to the generous hospitality of the Canadians and the detailed arrangements made for the Forestry Conference as a whole, but also to the unstinted trouble taken both by the Canadian authorities and by private persons to arrange special visits of particular forest products interest which were not in the official programme. At the Forest Products pre-Conference meeting the progress of the past five years was reviewed, technical discussions were held on all aspects of timber technology, and resolutions were prepared for presentation at the plenary Conference.

From 6th to 22nd September, the Officer in Charge, Mycology Section, visited institutions of mycological interest in Paris and elsewhere in France, and attended a joint meeting of the British and French Mycological Societies held in Normandy.

The Officer in Charge, Wood Structure Section, served during the year on the Working Party on the Production and Consumption of Tropical Timbers convened by the Organization for European Economic Co-operation. Three meetings were attended in Paris.

ADVISORY PANELS

Once again thanks are accorded to those industrial associations and government departments who have provided members of the Laboratory's informal advisory panels, and to the members themselves for their unsparing help. Owing to loss of the relevant members of the Laboratory's staff the Radio Frequency Panel has not met during the year, but the Adhesive Makers' Panel and the Plywood Research Panel have met as usual to discuss projects of interest in the programme of research.

THE FURNITURE DEVELOPMENT COUNCIL

Close collaboration has been maintained with the Council, mainly through its research department, which is now established in its laboratories at Redhill,

where excellent work on the testing and principles of construction of furniture is being carried on. This collaboration provides a very pleasing example of the utilization of the Laboratory's research data on the special problems of an industry.

PUBLICATIONS AND RECORDS

Four new publications were issued through H.M. Stationery Office during the year. They were two Annual Reports, the "Kiln Operator's Handbook", and Bulletin No. 25 " Identification of Hardwoods. A Lens Key ". The Kiln Operator's Handbook, which is based on the subjects covered in the Laboratory's courses for trainees in the seasoning of timber, fills the need for a book to which kiln operators can refer during the course of their work. The " Lens Key " Bulletin meets the demand for a practical method of identifying commercial hardwoods, some 400 of which are dealt with.

Revised editions were issued of Bulletin No. 1 (the fifth edition) " Dry Rot in Wood", and of three of the numbered leaflets. Leaflets describing the properties of another twelve tropical timbers not generally familiar to Industry were prepared for distribution to firms requiring the information. These and the other reports published during the year, including thirty-three papers in the scientific and technical press, are listed in Appendix II. Twenty-one other reports were prepared for limited circulation.

THE ADVISORY SERVICE

The number of enquiries answered by letter or report, which is taken as a measure of the volume of advisory work during the year, was 6,300. The number of technical visitors and telephone enquiries has been correspondingly large. Enquiries answered by letter, after remaining steady for three years, have again risen. As other technical advisory services such as that of the Furniture Development Council, develop, some enquiries will be diverted from the Laboratory, but any relief afforded by such technical services will, for a long time to come, be more than offset by the reverse flow from them of enquiries falling within the Laboratory's province. Thus the volume of advisory work is likely to increase rather than to diminish, and the burden on a limited staff to become greater. It is nevertheless a welcome and indeed a necessary burden, since it not only shows that the work of the Laboratory is becoming more widely known and applied, but also enables the trend of general industrial problems to be gauged.

The number of leaflets issued in reply to standard enquiries was 52,300.

PROGRAMME OF RESEARCH

WOOD STRUCTURE

Continued restrictions on the imports of softwood and of many of the traditional commercial hardwoods have maintained the interest in Colonial timbers. They are being more generally accepted as standard timbers, particularly where the quality of the final products is not associated with the technical or aesthetic characteristics of a particular kind of timber. A recent review of the timber situation shows that the increase in the consumption of tropical timber as compared with pre-war has been greater in the United Kingdom than in any other Western European country. The following are some of the principal

purposes for which tropical timbers are being used in place of the traditional European and North American species: furniture (principally furniture interiors, core-stock, linings and backings), building work which does not qualify for a softwood licence, flooring blocks and strips, road vehicles (principally the under-framing of buses, motorcoaches and motor lorries) and the under-frames of railway wagons.

Collection of Timber Specimens

Approximately five hundred timber specimens have been added to the reference collection during the year. They include valuable contributions from the Forest Departments of North Borneo, Kenya, Northern Rhodesia, Southern Rhodesia, the Philippine Islands and Brazil, and the Forest Products Laboratory, Madison, U.S.A., as well as many miscellaneous specimens from official sources, private collectors and from the timber trade. Grateful acknowledgement is made to all who have helped in this way to keep the Laboratory's collection up to date.

Over two thousand small hand specimens of timber have been distributed during the year, in exchange or in response to enquiries on technical questions. This number is considerably smaller than in previous years, as specimens of the principal timbers of commerce are now being supplied through commercial channels and a number of requests for sets of specimens have been referred to this alternative source of supply.

Identification Studies

The Laboratory's lens key to the identification of hardwoods has been published as Forest Products Research Bulletin No. 25[1]. It has also been arranged for H.M. Stationery Office to retail the perforated cards necessary for preparing the card key from the coded descriptions given in the Bulletin. It is too early to say whether this will lead to an immediate appreciable decrease in the number of timber specimens submitted to the Laboratory for identification but it should eventually do so.

A general key of this kind is essentially a preliminary sorting method. The precise identification of an unknown timber usually depends on comparison with an authentic specimen, an anatomical description or a photomicrograph, or on the use of a special key to a limited taxonomic or geographical group. To meet the needs of those who have no access to a representative collection of timber specimens or to a technical library, a companion volume of low-power photomicrographs ($\times 10$ magnification) of the four hundred timbers dealt with in the lens key has been prepared for publication[2]. A selection of the photomicrographs is shown in Plate 2.

In the course of preparing this Atlas certain improvements have been developed in the technique of producing photomicrographs of this kind. The general procedure was to soften the selected wood blocks by boiling in water, to trim the end-surface on a heavy sledge-type microtome and then to put the blocks aside until the prepared surface just appeared uniformly dry. Beyond this stage difficulty was sometimes experienced owing to surface checking of

[1] Identification of Hardwoods: A Lens Key. *Bull. For. Prod. Res., Lond.*, No. 25. H.M.S.O., 1952.

[2] An Atlas of End-grain Photomicrographs for the Identification of Hardwoods. *Bull. For. Prod. Res., Lond.* No. 26. H.M.S.O., 1953.

the blocks under the heat of the illuminating lamp of the photomicrographic apparatus. This difficulty was finally overcome by applying transparent cellulose adhesive tape to the surface immediately it was dry. This had no adverse effect on definition and in some cases improved it.

Physiology of Heartwood Formation

Action on the main experiment in which the effect is being studied of a special form of girdling on standing oak and larch trees has been confined to routine observations. No marked increase in the rate of heartwood formation has so far taken place.

A supplementary experiment on oak has been concluded in which a bark girdle was cut at the top of the bole in addition to the main girdle at the base. This prevented the replenishment of the food reserves in the trunk by fresh supplies from the crown and was intended to create, artificially, conditions of food shortage in the sapwood as a whole similar to those which obtain normally in sapwood which is about to be transformed into heartwood. Examination of the felled stems showed that no significant development of heartwood had resulted from this double girdling treatment but interesting results in other directions were obtained. Thus, observations made on the wood formed above the top girdle showed that the unusual conditions of nutrition and sap conduction occurring there had had a marked effect on the structure of the wood. The proportion of storage tissue (rays and parenchyma) and fibrous tissue had increased considerably whereas vascular tissue was reduced compared with the normal earlier-formed wood.

Another feature of interest was that although, at the main girdle, no healing callus developed, another wound reaction was observed, viz. the formation of tyloses. The evidence afforded by this experiment suggests that callus formation is dependent on substances derived from the leafy crown (the supply in this experiment being cut off by the top girdle) but that in tylosis formation local stimulus alone is sufficient and that food substances available in the immediate vicinity can provide all the raw material required.

This part of the experiment has been terminated owing to the onset of fungal attack in the experimental trees following the depletion of the food reserves.

Advisory Work in Wood Structure

Most of the enquiries submitted to the Wood Structure Section involve the identification of timbers (over 1,500 specimens have been identified in the course of the year) and frequently, in addition, advice on technical characteristics, quality, suitability for various purposes, supplies and alternative timbers. Conditions in the timber-using industries are reflected in the number of enquiries for substitute timbers and requests for basic information on unfamiliar species being offered on the market, some of which are not to be found in standard reference books. The series of leaflets on some of the recently introduced timbers is useful for answering enquiries on these specific timbers but much time is spent in preparing information on other timbers. This information is based on the examination of hand specimens together with such technical data as are available in the Laboratory's records.

The nature and significance of abnormalities is also a frequent subject of enquiry. Examples of these are resin-ducts simulating worm-holes, brittleheart in tropical hardwoods, tension wood causing distortion and splitting, resin-

exudation in seasoned timber and differentiation of sapwood and heartwood in light-coloured timbers.

There has been a noticeable increase in the number of enquiries from overseas. Requests for information and advice have been received from a furniture manufacturer in Southern Rhodesia, building contractors operating in Kenya and Mauritius, bobbin manufacturers in India and the U.S.A., an armament factory in Scandinavia, American importers of tropical timbers and members of E.T.A.P. missions operating on behalf of F.A.O. in under-developed countries.

Enquiries of archaeological or antiquarian interest have included a centering peg from the base of a pillar in the Parthenon in Athens, structural timbers from a 12th century Turkish mosque and from Malta cathedral, and remains of charred wood from excavations of the Viking period.

The number of outside enquiries involving a written reply amounted to 694.

SEASONING

Kilns and Kiln Seasoning

During the course of the year the large kilns have been used for the drying of opepe, andiroba, bisselon and obeche.

The presence of tension wood had caused the partly dried andiroba to distort badly but by careful piling, weighting and steaming the load at high temperatures initially and finally, it was found possible to produce kiln-dried material that was in much better shape than initially. The bisselon dried as well as the less dense African mahogany, and it was found possible to dry the 1-in. obeche very satisfactorily, using a much more severe schedule than had so far been recommended, in a period of just less than four days.

In the smaller kilns, experimental loads of kurokai, wamara and alstonia have been dried. With the exception of alstonia, these species must be regarded as refractory.

The first of a series of tests on the seasoning of home-grown softwoods has been carried out and consignments of Sitka spruce from two localities have been seasoned at high and low temperatures. In addition, the intermediate size kilns have been used for drying consignments of test material for the Timber Development Association (oak and teak) and the Furniture Development Council (beech) and for use by various sections within the Laboratory.

The construction of a new model kiln capable of accommodating an exceptionally wide pile has been completed. In this it is intended to study the effects of pile width and air speeds on drying times.

The Seasoning of Birch for Brush Woodware

Brush and broom heads are generally manufactured from birch and the timber is usually stacked on end in pole form for periods up to about twelve months before it is turned. With this method of seasoning, drying proceeds unevenly and appreciable losses are incurred through splitting and dote. If the timber is used before it has been adequately dried, end-checking often occurs on the turned brush heads to such an extent that they have to be rejected.

Experiments have therefore been made in the hope of finding an improved method of seasoning which would be sufficiently cheap and simple to permit its use by the relatively small firms engaged in this trade.

A preliminary test showed that poles can be dried satisfactorily in a kiln, but the drying rate is necessarily slow and the cost prohibitive. Various other methods were tried but finally the possibility of producing the fully shaped brush heads from green timber and drying them afterwards was investigated. Without chemical treatment it was found almost impossible to prevent checking on the ends of these pieces. Soaking for six hours in saturated urea solution rendered them more tolerant of comparatively severe drying conditions, however, and the tests showed that they could then be dried quickly and satisfactorily either in a kiln or warmed store. Whether this method will prove feasible and economical when used on a large scale in practice has yet to be determined.

An article giving the results of this work has been prepared and published[1].

Kiln Drying of East African Pencil Cedar Slats

At the request of a firm of pencil manufacturers experiments have been carried out to determine how well pencil cedar slats can be kiln dried if piled by the end-lapping method.

Employing a temperature of 60°C a load of 5,000 slats was dried to a satisfactorily uniform moisture content of about 10 per cent in 3½ days and there were indications that this time could be still further reduced. Drying and conditioning slats in compact bundles of about 250 in the manner commonly adopted takes about six weeks and it remains for the firm to assess how much the faster rate of drying will offset the higher labour costs involved in the open piling of the slats.

The effect of variations of moisture content in the slats on any subsequent distortion is also being examined.

Seasoning in Superheated Steam

In order to extend the small-scale investigation into the drying of timber by superheated steam mentioned in the Report for 1951, one of the intermediate size kilns has been adapted so that the necessary conditions can be obtained.

Three loads of 2-in. green home-grown Scots pine have been dried, two using superheated steam and one, of matched material, employing the kiln schedule No. 8 as normally recommended for this species.

In the first superheated steam run, using temperatures from 110° C (230°F) to 117°C (243°F), the pine was dried from an average of 83 per cent to 10 per cent moisture content in about three days. The timber suffered considerably more checking degrade, but only slightly more shrinkage and distortion than the matched material dried in accordance with schedule No. 8 in ten days. Lower temperatures of from 108-113°C were used for the second run but the final condition of the timber was no better than before. In this load were included some dozen scantlings of home-grown Sitka spruce and these dried without splitting, but considerable collapse and honeycombing occurred.

Loads of 1-in. green and partly dried beech were seasoned at temperatures over the boiling point, but distortion and checking were unduly extensive in amount, particularly in the material dried from the green.

Loads of Scots pine boards 1-in. thick were, however, dried quite successfully at temperatures of the order of 110°C in about a day and a half as compared

[1] JOHNSTON, D. D. Some Experiments on the Drying of Birch for Brush Woodware. *Wood*, 1952, **17** (10), 378-384.

with the four days required to dry matched material in accordance with the normally recommended schedule No. 8.

These results tend to confirm the view that the normal schedules provide a considerable safety factor for the seasoning of certain softwoods and possibly for light-weight hardwoods, but that the safety margin is much smaller for the general run of hardwoods or of species liable to collapse.

Shrinkage Tests

Experiments have been put in hand to obtain information on factors that affect the shrinkage of wood during drying. Beech has been chosen for these tests and the samples restricted to a thickness of $\frac{1}{8}$ inch along the grain to prevent as far as possible the development of stresses during drying. Matched samples were both dried slowly and quickly at six different temperatures and to control the slow drying rate special apparatus was developed and housed in a model kiln. Results so far obtained have indicated that shrinkage in drying slowly from the green state to zero moisture content was progressively greater as the temperature at which the wood was dried increased. Samples dried very rapidly, however, tended to shrink rather less at the high temperatures than at the low. Shrinkage/moisture content curves also have been obtained for tangentially cut specimens dried slowly at high and low temperatures (Fig. 1).

These show (a) that there is a tendency for the wood at high temperatures to expand during the initial stages of drying, (b) that shrinkage starts at a moisture content of about 50 per cent, (c) that shrinkage at the high temperature becomes roughly proportional to the moisture drop from an initial moisture content of about 45 per cent, and (d) shrinkage at low temperatures becomes proportional to moisture content drop from an initial moisture content of about 30 per cent.

These results are of some significance in kiln drying as they confirm the general finding that green beech subjected to a high temperature drying schedule tends to shrink and hence to distort more than, say, air-dried beech.

Moisture Content Distribution in Wood with One Face in Contact with Water

Tests have been carried out to determine the shape of the moisture gradients in wood samples when for a long period one face of each has been in contact with water and the other exposed to air. Such conditions are experienced in practice by boat, vat and such-like timbers.

Trays of Douglas fir and oak were fashioned and a small head of water was maintained on the one face of each for periods of up to one year. The lower faces of each were exposed to air at two different humidities, and in one instance this lower face was coated with bituminous paint.

At the end of the exposure period moisture distribution tests were made and these showed that the moisture drop from the wetted face to a depth of about $\frac{1}{5}$ the thickness of the wood was very steep indeed. At this depth the moisture content was of the order of 30 per cent. On the exposed surface the moisture content tended to become slightly but not very appreciably higher than the equilibrium moisture content corresponding with the humidity of the surrounding air. Coating the dry face with bituminous paint appeared to have surprisingly little effect on the moisture distribution as a whole. Further work on these lines is in progress.

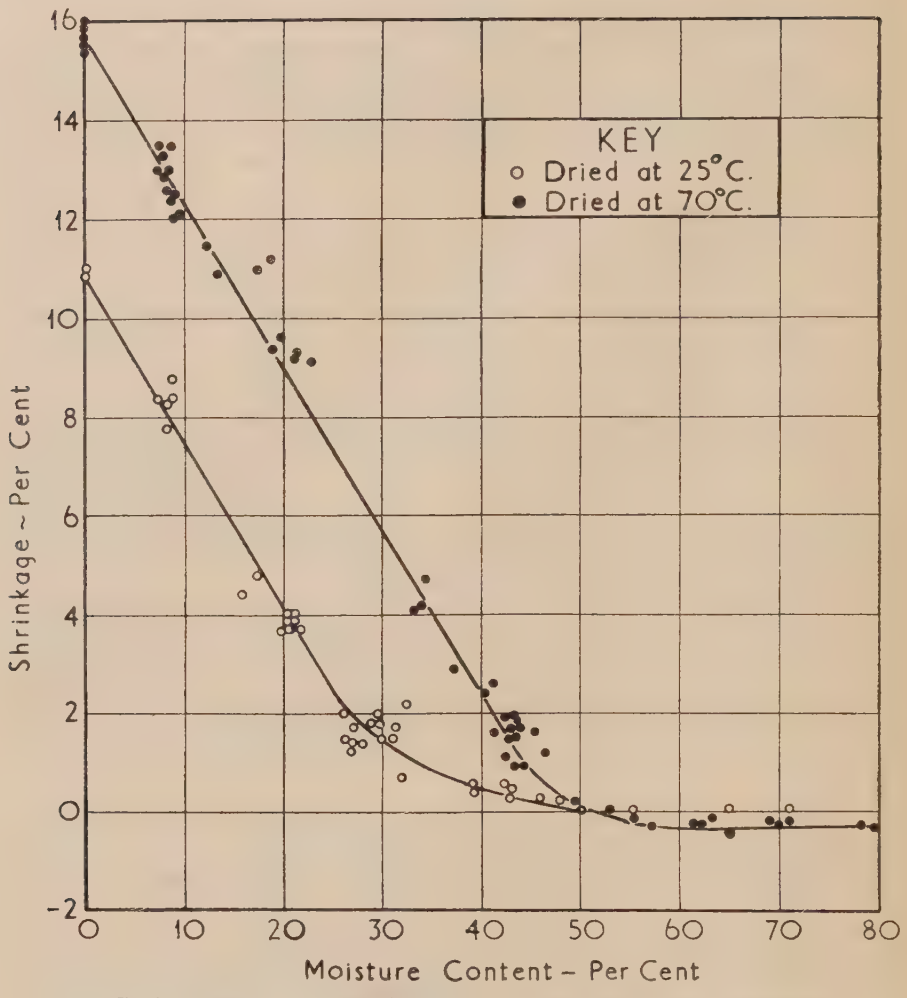


FIG. 1. EFFECT OF TEMPERATURE ON THE SHRINKAGE OF BEECH

Wood Bending

The routine testing of timbers to determine their bending properties has been continued and data on some nine different species obtained. Timbers tested included kokrodua, brown sterculia and courbaril.

None had bending properties equal to, say, beech, but of those tested the courbaril was the most promising and appeared to be suitable for certain type furniture bends. A large-scale series of steam bending tests on a consignment of ash logs from Selsey Forest, Northants, was carried out at the request of the Forestry Commission. The results showed that intrinsically the material possessed very good bending properties, but that much would be rendered unsuitable for bent work because of the prevalence of small knots, which proved very detrimental to the bending.

Work on laminated bending has included the determination of basic data on

the limiting radii of curvature of nine different hardwoods. Tests made to determine the influence of the direction of growth rings relative to the axis of curvature have indicated that the effect is negligible in the case of ring-porous hardwoods. The best results were obtained with softwoods, however, when the growth rings were normal to the axis of curvature.

There has been some demand from the boat-building industry for information on the most suitable technique to be employed in the making of laminated bends of large and sometimes varying cross-section, such as boat stems, hulls, frames, etc. In this connexion a provisional programme of tests has been prepared. In the first instance it is proposed to make up a few boat stems with a view to investigating the possibilities and limitations of various bending methods. These stems will be used to determine the forces induced and the influence of mechanical restraint on the glue layers when they are immersed for a period in water.

The influence of various factors such as jig temperature, speed of bending, etc., on the bending of plywood has been investigated and standard tests carried out on three-ply made from kurokai.

Very considerable interest has been shown by the furniture and other wood-using industries in the new process developed at the Laboratory for making plywood corners of small radius. Data relating to the possibilities of using timbers other than balsa for the insert required for bending plywood in accordance with this process have been obtained. Woods found to be suitable for this purpose include bombax and erimado. It has also been established that for certain purposes insulating board is suitable for the insert. A patent application is pending and an article describing the process has been prepared for publication.

At the request of the Brewers Society, tests have been undertaken to find a suitable substitute for oak in the manufacture of beer barrels. Barrels have been made of dahoma but unfortunately this species has been found to be generally unsatisfactory for this particular purpose.

Co-operation with the Trade

Co-operation with the trade was maintained throughout the year and 60 visits were made to firms interested in seasoning and bending.

The number of enquiries received during the year in connexion with seasoning and bending amounted to 1,090. This represents a considerable increase on the previous year.

TIMBER MECHANICS

Testing of Timber for Comparison of Species

The testing of timber for the comparison of species has continued throughout the year and strength data have been obtained for binuang, m'bambakofi, nyankom, Parana pine and ramin. Tests are now in progress on wamara and a consignment of home-grown ash.

The investigation to establish correlation between the schemes of testing for the 2-in. and 2-cm size test specimens has continued. Further tests on matched specimens of the two sizes taken from additional species have been completed and others are in progress.

A study of strength data in comparison with results of steam bending tests has been carried out in order to examine the possibility of evaluating bending

quality from strength tests on clear specimens of timber, and a report dealing with the study has been prepared.

The Structural Use of Timber

Tests have been carried out on industrial type roof trusses of different spans and on a large box beam, using the system of loading, described in the Report for 1951, which applies a series of equal point loads by means of a continuous wire rope and a system of pulleys. The applied load is measured at the points of support of the structure under test using pressure gauges attached to hydraulic capsules. The different tests carried out during the year illustrate the adaptability of this method of testing to a wide range of structures.

A large industrial truss, of span 59 ft. 2 in. between intersection points, of the same design as the one tested last year, and using toothed shear-connectors at the joints, has been tested for the Timber Development Association. The timber used in the truss was a mixture of Douglas fir, spruce, silver fir and Baltic redwood and, as specified in the design, was limited to defects not greater than those allowable for an 800-lb. grade. The truss failed under a load of 13·5 tons compared with 9·9 tons in the previous test. This increase in load was due to the use of better quality timber, the first truss having had members which did not conform with the grade specified. The main failure in the second test occurred at a small knot in the bottom tie.

A further test on an industrial type roof truss of span 46 ft., designed to carry ceiling loads on the bottom tie in addition to the normal roof loading, has also been carried out for the Timber Development Association. The joints in this truss were made with split-ring shear connectors. The purlin point loads were applied with the " pulley-wire rope " system and the ceiling load with dead weights at the panel points on the bottom tie. The truss failed under a load of 13·7 tons.

To investigate the use of glue as a jointing medium in truss construction, five small trusses of span 19 ft. $10\frac{3}{4}$ in. and pitch 30° have been constructed. These trusses and one tested previously with tooth-plate connectors were all of the same design, so far as the members were concerned, but differed in the type of joints. The timber used was high-grade Scots pine, the corresponding members in the different trusses being matched one with another. Three of the trusses were jointed with a casein glue and two with a cold setting ureaformaldehyde glue, gluing pressure being obtained at the joints with $\frac{3}{8}$-in. diameter bolts. One of the casein-jointed trusses was tested and carried a load of 7·9 tons without failure, the matched connector-jointed truss having failed under a load of 6·4 tons. The glued truss was nearly 50 per cent stiffer than the connector one and had a recovery of deflection of over 90 per cent at working loads. The other four trusses have been loaded and will be left for an indefinite period to provide information on their behaviour under long-term loading, the bolts having been removed from one truss made with each type of glue.

A box beam, 40 ft. long, 24 in. deep and $6\frac{1}{2}$ in. wide, has been tested at the request of a commercial firm. The top and bottom flanges were made up from three lengths of clear Douglas fir of cross-section $6 \times 2\frac{3}{4}$ in. scarf-jointed together to give a continuous 40 ft. length. Vertical stiffeners at centres of 20 in. were embodied in the construction and each side of the box beam was covered with 6 mm gaboon plywood with the face grain parallel to the length of the beam.

The plywood was made up of six lengths on each side, scarf-jointed together with a slope of about 1 in 5. The plywood was glued to the framing of the beam, gluing pressure being obtained with galvanized wire nails. The beam, supported on flat timber pads 40 in. long to give a span of 30 ft. with a 5 ft. overhang at each end, carried a load of 17·1 tons without showing any signs of failure and the recovery of the beam on removal of load was over 95 per cent.

Two consignments of home-grown Sitka spruce received from the Forestry Commission, one from Inverliever in Scotland and the other from Gravetye forest in Kent, have been graded and tested for strength in structural sizes. There was a marked difference in the rate of growth and density of the two consignments, which was reflected in the strength properties of the clear material taken from the joists. The increase in most of the strength properties of the denser material from Gravetye was appreciable. This denser consignment, however, gave only slight increased bending strength in the structural sizes, owing mainly to the presence of bigger defects, particularly knots, although these were still within the limits of the particular grade.

The Strength of Struts

A new project designed to provide information on the strength of struts of the type used in light constructional work has been started. Its purpose is to determine the most suitable design formulae for this type of strut and to formulate stress grades with reference to visible defects. Three variables, cross-section, slenderness ratio and grade of timber, are important factors affecting the strength of timber struts. For the first of these, four cross-sections in common use in light constructional work are being investigated. The effect of slenderness ratio is being studied by using seven different ratios of length to minimum cross-sectional dimensions varying from six to fifty.

It is well known that with short struts where the slenderness ratio does not exceed about eleven, the critical property is the compressive strength of the timber. Where the ratio exceeds forty, failure occurs by buckling and the failing load is dependent on the stiffness or modulus of elasticity of the timber, while for struts of intermediate length failure occurs by a combination of buckling and crushing and the failing load depends on both modulus of elasticity and compressive strength. Additional tests on small clear specimens end-matched with each strut are in progress to establish these values.

The Strength of Shear Connector Joints

A further series of tests has been carried out to determine how the load on a shear connector joint is distributed between the bolt and the connectors and at which point of slip each component develops the maximum strength. Three matched groups of test pieces consisting of three-member joints were prepared. The first test joints were assembled each with a 2-in. " Bulldog " connector and $\frac{1}{2}$-in. diameter bolt, the second with $\frac{1}{2}$-in. bolts only and the third with the shear connector only. The last assembly was achieved by slotting the bolt hole in the direction of loading so that the load was carried wholly by the shear connector. All the joints were tested in compression parallel to the grain.

The results showed that the joints with bolts alone had a maximum load of about twice those with the connectors only, while the load on the bolted connector joint did not exceed 90 per cent of the sum of the maximum loads carried

by the components, since these occurred at different slips. A paper giving the results of these tests and of all previous tests has been published [1].

The Strength of Nailed Joints

A programme of tests has been started to determine the strength of joints made with round wire nails. The tests are designed to study the effect of the three variables, (1) the type of loading, whether single or double shear, (2) the number of nails used to make the joint, and (3) the thickness of the members joined. The results of preliminary tests show that joints using 2-in. 12-gauge nails in double shear are about 60 per cent stronger than those with the nails in single shear and they also indicate that the strength of the nailed joint is directly proportional to the number of nails used, within the range 1-4 nails. The investigation is continuing.

The Testing of Plywood

The project for the testing of plywood begun last year had as its main object the provision of fundamental strength data to enable comparison to be made between different species. The large number of plywoods of different species which are now available and their increasing use for structural components, as in box beams and composite panels, have prompted an expansion of the project to include two additional studies. One of these has as its purpose an examination of the effect of the geometry and the thickness of the veneers used in the construction of plywood upon its strength, and the other an investigation of the design and performance of plywood components in structures and the determination of working stresses. Working plans are being prepared for these two studies.

Considerable progress has been made during the year under review with the original part of the project and tests to compare the strength properties of $\frac{3}{16}$-in. 3-ply wood of twenty-five species have now been completed. A report on this work is being prepared.

The Wood of Aircraft Wings

An investigation was made to determine if a deterioration of the wood used in the construction of aircraft wings had been caused by the climatic conditions under which the wings were operated or by the stresses imposed during flight. The main spars from the starboard section of three wings were examined. These wings were manufactured in 1943, 44 and 45 and had had 391, 491 and 4 hours' flying, respectively. The main spars of box type construction, were made from laminations of Sitka spruce 0.40 in. thick in the bottom booms and 1.5 in. thick in the top booms.

After a visual examination had been made, tension and compression tests were carried out on small specimens taken from the spars, as well as a microscopic examination of the wood fibres from various sections.

The visual examination showed no evidence of deterioration. Slip planes which are said to be microscopic compression failures in the walls of individual fibres, were present in most of the material but these could not be taken as significant evidence of deterioration since it was found that they occurred in equal intensities in dry unstressed spruce. A statistical analysis of the strength

[1] Brock, G. R. "The Strength of Toothed-plate Connector Joints." (F.P.R.L. Neostyled Report, 1952).

test results and a comparison with normal spruce figures showed that there was no reduction in compression strength but that there was a greater number of low tension results than would have been expected from a similar sample of the normal unstressed material. No evidence was found, however, to show conclusively that a definite deterioration in quality of the spruce had occurred. The possible deterioration indicated by the low tensile figures would have had little if any effect on the strength of the structures as a whole.

The Effect of Temperature on the Strength of Timber.

The effect of temperature on the strength of wood may be either permanent or temporary. Permanent effects result from prolonged exposure or exposure to successive cycles of high or low temperature; this effect is a function of duration of temperature as well as of temperature itself. Temporary or transitory effects are those which exist only at the particular temperature involved. In general any increase in the temperature of wood above normal results in an appreciable decrease in all the strength properties, with the exception of deflection at failure, and possibly of resistance to suddenly applied loads, or toughness. The extent to which this occurs will depend on the moisture content of the wood, its specific gravity and the temperature itself.

In the kiln drying of wood the tension stresses set up across the fibres are of special significance. Surface checking, case-hardening and honeycombing are all seasoning defects directly associated with these stresses which are induced in the timber by uneven drying. A knowledge of the strength and elastic proporties of timber in tension perpendicular to the grain, at various temperatures and moisture contents, would promote a more complete understanding of fundamental seasoning problems, and an investigation with this end in view has been started.

Of the various types of tension test piece at present in use, one common feature is generally a " waisting " or a reduction in the central cross-sectional area, to induce failure to occur away from the ends where the specimen is gripped. This type of test piece has not been completely satisfactory in all cases and in the present series of tests it was decided to use a specimen of uniform cross-section. To grip this test piece a metal block of the same cross-sectional area is glued to each end using a synthetic resin adhesive. In testing, a more uniform stress distribution is obtained across the specimen than when wedge grips are used and stress concentrations at the ends are reduced to a minimum. The load and the gross extension of the test piece are obtained automatically on the testing machine.

Initial tests have been made at various controlled conditions of temperature and humidity by installing the testing machine in a kiln, a technique of testing which has been found to give satisfactory results over the range of temperatures used, 20°–40°C. These tests have shown that, with increase in temperature, there is a significant decrease in tensile strength perpendicular to the grain and in the modulus of elasticity.

With a view to testing at higher temperatures, a circular chamber which completely surrounds the test piece has been designed for use with the testing machine. Two rods connected to the straining mechanism of the machine pass through openings at either end of the chamber for attachment to the test specimen. The temperature within the chamber can be accurately controlled by circulating heated water between an outer and an inner wall. To ensure

the constant moisture content of the specimen when it is heated to the required temperature it is enveloped in a thin tightly fitting latex rubber coating. Preliminary experiments using this apparatus are in progress.

Performance Tests of Doors

The work on the slamming and torsion tests of doors which was undertaken at the request of a British Standards Institution Committee has been completed. Besides the main conclusions regarding the performance level of flush and panelled types of doors summarized in the report for 1951, further information bearing on the construction and use of doors has been included. The work has been augmented by a further series of slamming tests on flush doors with hardboard or plywood facings, obeche or softwood framing and cellular and other core infill. These tests were made on a modified version of the automatic slamming machine which expedited the tests by increasing the rate of slamming from four to twelve slams per minutes, the other test conditions remaining as in the original apparatus. A supplementary report on these additional slamming tests has been submitted to the Committee.

A test for determining resistance to puncture has been developed.

Abrasion

Standard abrasion tests have been carried out on silky oak grown in South Africa to examine its suitability for industrial and other types of flooring. Tests have been made at the request of the Conservator of Forests, Uganda, to assess the suitability of mubura for heavy duty industrial flooring and for other purposes where the property of resistance to wear is of importance.

Many requests for information on the suitability of a number of hardwoods from Japan for use as flooring, in particular the species of beech, birch, maple and oak grown in that country, have been received. These Japanese species do not differ very markedly in anatomy from the corresponding woods well known to the flooring trade in this country and, so far as resistance to wear is concerned, can be assumed to compare favourably. A test at the request of a firm of timber merchants has confirmed that Japanese maple ranks very high in resistance to abrasive action and is equivalent to Canadian rock maple in this respect.

The relative wearing qualities of two types of wax-impregnated veneered boards have also been tested.

Timber Mechanics: Miscellaneous Investigations

Ad hoc investigations have been carried out at the request of several manufacturers. These include testing of picking sticks in both solid and laminated blank form to provide data for assessing their relative merits; testing of impregnated and compressed laminated beech to provide information on its strength properties; and testing of solid and jointed elm and agba Windsor chair seats to determine proof loads for use in the production line. A series of tests on cedar, Japanese larch and Douglas fir impregnated telegraph poles has been made at the request of the Forestry Commission.

Advisory Work in Timber Mechanics

A total of 273 enquiries concerned with miscellaneous aspects of strength, have been dealt with during the year under review. Advice has been given to

government departments and to the Timber Development Association on many matters connected with the structural use of timber. Assistance has also been given to the British Standards Institution in connexion with the preparation of standards for lattice steps and ironing boards and to the Ministry of Supply in connexion with their specification for ammunition boxes.

The utilization of timbers for flooring, in particular the relatively unknown hardwoods now being imported in increasing quantities from the Commonwealth and other countries, has continued to be of importance in the advisory work of the Section. A total of 135 enquiries concerning wearing qualities and floor treatments have been answered.

COMPOSITE WOOD

Properties of Adhesives

Several of the series of long-term durability experiments upon adhesives for plywood manufacture and assembly work have passed their fifth year, and the accumulated data have been analysed and correlated with the results of older and less comprehensive projects. The findings can be summarized thus :—

Under *Indoor Conditions*, sodium silicate is the only glue to have failed, but urea resins extended with 50 per cent or more of flour are weakening. All other adhesives show no significant change.

Semi-outdoor Exposure, in which test material is stored in an unheated ventilated shed, has shown that urea glues extended with 30 per cent or more of flour are suspect. Casein and animal glue in plywood would probably survive this exposure if condensation were absent. In assembly joints, performance has depended on the size of the joint; in large glued areas, animal, casein and synthetic resin adhesives have been satisfactory, but under slightly less favourable conditions, where slight condensation, mild insolation and occasional driven rain have reached small plywood-to-solid wood joints, animal and casein glues have failed and urea glues have weakened considerably.

With *Full Weathering*, only phenolic and resorcinol glues have survived. The times for the other types to reach a defined state of failure are of the following order :—

Glue type	Plywood	Assembly joints	
		Small	Large
Animal	1 month	4 months	12 months
Casein	4 months	12 months	2-3 years
Urea	2 years	2-3 years	5-6 years
Fortified urea	3-5 years	—	—
Melamine	4-6 years	—	—

These tests were begun five years ago, and do not, of course, include the more recently developed adhesives. The methods of glue testing were also contemporary. Comprehensive plans for extended experiments have now been prepared in consultation with the Adhesive Makers' Panel. New types of

adhesive and improved forms of existing glues will be included in the trial. A means of protecting the wood from weather and fungal attack will also be found for with the most durable glues it is the wood component of the assembly that fails, particularly in large-surface, small-bulk material such as plywood.

The experiments should also determine more fully the limiting conditions of service of the urea type glues. These are cheaper than phenolics and more readily available, and in times of war the use of these latter would no doubt be restricted to essentials.

Data should also be obtained upon the durability of glued joints made from solid wood or veneer pre-treated with preservative.

From experience with the old patterns, new types of test pieces have been developed and methods of examining and proof-testing defined and simplified. By these means, it is expected that the routine labour of these long-term experiments will be reduced.

The glue-testing work in collaboration with H.M.S. *Hornet* has now completed its third year. The experimental motor torpedo boat itself is in need of repairs, particularly the deck and superstructure, and the Laboratory is carrying these out as part of the general investigation. The gluing of timber under shipyard conditions is part of the programme, and a tour of boat yards was made recently to study the problems on the site.

The Tropical House is now in continuous operation, and several firms have accepted the Laboratory's offer of storage space to study the behaviour of their packaged adhesives under export conditions.

The examination of three Mosquito wings and one Canberra fin has been undertaken at the request of the Ministry of Supply to see if age or service had deteriorated the glued joints. This has involved the piece-by-piece stripping of the wings, and the examination of a very large number of joints. It was shown that any deterioration of the glue that might have occurred was completely masked by the variation in workmanship in the original making of the joints.

Early in 1952, the Association of British Plywood Manufacturers convened a meeting of glue makers and Service users to discuss recent troubles experienced with the new phenolic glues setting at 100–120°C as they had been found erratic in their performance. As a result, the Laboratory has since done small- and large-scale testing of improved forms of adhesive prepared by resin makers. This is an excellent example of the direct use of the Section's plywood plant for assisting in the solution of an industrial problem.

Work connected with the revision of B.S. 1203 " Synthetic Resin Adhesives for Plywood " has continued and in February of 1952 a third draft of the paper was sent by the Laboratory to the British Plastics Federation for comment. There was sufficient agreement between the Laboratory and the Federation for the draft to be formally passed to the British Standards Institution.

Trials of Timbers for Plywood Manufacture

In the trials of timbers for plywood manufacture, a further twelve species have been put through. The system by which these trials are made was devised in collaboration with the Plywood Research Panel and issued as a Manual in August 1950. Experience has shown how the original scheme could be improved

and brought still nearer to industrial practice, and a Revised Manual (P.R.P. 8/1) of June 1952 has been issued. A simple classification scheme based on the derived data has been evolved by the Plywood Research Panel in which a timber is assigned to one of four groups:

I—The timber has been used successfully in British mills.

II—The species is believed to be suitable for use in British mills.

III—The timber is unsuited to British mills but is technically sound for plywood making and might be of value for this purpose in its country of origin.

IV—The species is considered either unsuitable or undesirable for plywood making because of its weight or processing difficulties.

The Panel has classified the first twenty-six timbers tested by the Section and a short paper has been issued.

Special Heating Methods for Glue Setting

Changes in staff have unfortunately held up all research work upon special heating methods for glue setting, although it is apparent from the industrial enquiries received that there is still much to be done. It is hoped to restart the work, and with it the activities of the Radio Frequency Panel, in the near future.

Study of Plant and Machinery

Further study of the operation of the veneer lathe has indicated that some simplification of design is possible without loss of efficiency. The taking of observations and measurements is proceeding, but the study is still at the laboratory stage.

The important operation of clipping the green veneer from the spool has been improved by alterations to the unwinding gear, conveyor and clipper. An experimental pre-selector gear has been fitted to the clipper enabling two fixed widths of veneer to be cut automatically, or any width in multiples of 3 in. by manually operated buttons. Some American machines have fittings for this purpose, but no British-made clipper has, and one object of the work has been to devise simple gear that a plywood manufacturer could readily put on to existing plant. Another object is to study the true value of pre-selector clipping in terms of speed of veneer flow, accuracy of width and the reduction of fatigue for the operator.

Heat quantities in the drying of veneer are being analysed. At present, 1·8 pounds of steam are being used in the " Dryad " for each pound of water evaporated from veneer, but the indications are that the efficiency can be improved by insulating the machine and modifying the air extraction system.

In veneer drying, a rapid means of determining moisture content is essential and the " Risborough Naiad ",[1] previously reported upon, has proved itself a useful tool. Single determinations can be made in ten minutes, and in continuous operation, forty per hour can be run. A further speeding has been effected by a complementary machine, the " Platen Oven " (Plate 3). This is a small press running at 200–250°C, which dries 0·064-in. veneer samples in 30 seconds, thus enabling a complete determination to be made in about

[1] Forest Products Research 1950, p. 31. (H.M.S.O.).

two minutes. The platens are heated by low-voltage current from a built-in transformer, and the apparatus includes a neon light timer.

Press-loading arrangements have been improved. The existing loader has been re-sited and runs in rails, thus simplifying lining up with the press. A special unloading truck has been built that takes the finished material as it is pushed out of the press by the ingoing cauls. With this combined loading-unloading system, dead time (i.e. the period in which the press does no useful work) has been cut from $1\frac{1}{2}$ or 2 minutes to 45 seconds, and a crew has been reduced from three men to two.

The standard method of evaluating the bond in plywood is the knife test, one drawback to which is the heavy manual effort required if the sample is made of thick hardwood veneer. A lever aid has been devised that considerably reduces the effort required without lowering the " feel " of the knife that is so necessary in the test.

Advisory Work in Composite Wood

During 1952, 475 enquiries were received from industrial sources.

WOODWORKING

Sawing and Machining Research

A study of the action of saw teeth has provided information from which it has been possible to formulate a tenable theory of cutting. The approach has been by (a) observation of chip formation in cutting at different angles to the grain, (b) determination of the forces exerted in cutting at right angles to the grain under different conditions of cutting angle and depth of cut, the length and thickness of the resulting chip and the angle of shear of the fibres also being measured, and (c) strength testing of wood in shear at different angles to the grain. Cutting under conditions such as in (b) consists of the cutting edge severing the fibres across their length by a combination of intense crushing, tearing and shearing. At the same time the severed material is continuously shearing parallel to the longitudinal axes of the fibres as the chip forms and passes up the tool face. The bundles of fibres ahead of those being severed are under lateral compressive stress and are bent forward in the direction of cutting. The shear parallel to the deflected fibres occurs in a plane extending from just above the cutting edge to the surface produced during the previous cut. The forces exerted at the tool face responsible for this deflection and shearing of the fibres consist of a compressive force normal to the face and a force parallel to the latter required to overcome frictional resistance to movement of the chip. In the case of a saw tooth, the resistance to cutting depends on the various forces required for severing the fibres at the front cutting edge, shearing at the side edges and " chip " forming at the tooth face. The relationship of this resistance to the volume of wood removed and to other factors can thus be established. An interesting result of this study was that the behaviour of the wood fibres at the cutting edge during severance provided an explanation of the characteristic change in shape of the edge as blunting occurs.

In the study of planing, special apparatus has been used to carry out extensive tests in cutting along the grain at different depths of cut and at cutting angles from 0°–40°. Chip formation under these various conditions

was observed and the forces parallel and normal to the direction of cutting were measured. It was noted in a series of tests on sycamore that at the relatively low speed of cutting employed there appeared to be two critical values for the depth of cut: (1) corresponding to the average fibre diameter, and (2) exceeding about 0·005 in. For depths below the first point (1), the relation to cutting resistance could be taken as parabolic in form whereas above this point, the relation was approximately linear, tight spiral chips being formed throughout. Above point (2), which obviously depended on the mechanical properties of the wood and the rate of cutting, the chip acted as a cantilever with periodic failure after riving. Further study of this matter is in hand.

Sawing Studies. Investigations on circular saws have included comparative tests of the performance of three types of inserted tooth, viz. (a) standard, (b) treated, and (c) tipped with Stellite. Standard teeth can deal successfully with many ordinary timbers but more wear-resistance is needed for material having an abnormal blunting effect. The siliceous timber makoré, being fairly representative of the latter class, was used in this study. The basis of comparison was the output obtainable for percentage increase in the power requirements of the saw, as this factor indicated specific degrees of blunting. The tests were carried out under normal conditions at a fixed feed speed of 40 ft. per minute. Precision methods were employed to obtain concentricity of the tooth tips so that all the teeth were in cut and shared almost equally in the work. As an example of the performance, for a 25 per cent increase in power the output from the saw when fitted with standard, treated and Stellited teeth was 8, 56 and 3,000 lineal ft., respectively, of 2-in. stock. The edge-life travel in the wood per tooth was in the three cases 52, 400 and 19,400 ft., respectively. Practical tests carried out previously under somewhat unfavourable conditions in a Colonial sawmill had given outputs from standard and Stellite-tipped teeth in the ratio of about 1 to 10. It should be realized, therefore, that the benefit to be derived from tipping the teeth depends largely upon care taken in preparation and use of the saw.

Other sawing tests have included measurements of power demand of narrow bandsaws at different feed speeds and tooth pitches, and the trial of a tungsten-carbide-tipped circular saw specially designed for cutting resin-bonded chipboards. The results of previous tests on circular saws were analysed and relationships of value in designing saws for use under specific conditions were established. A report has been prepared for publication dealing with investigations on spring-set circular plate saws carried out over a period of several years. It has been arranged chronologically to show how knowledge of the factors in sawing was gained and research technique improved. Information has been given on saw performance in relation to feed speed, depth of cut, hook, number of teeth and density of timber cut. Particular attention was paid to saws having comparatively few teeth and evidence is presented showing that the optimum number of teeth depends on the particular application of the saw.

Planing and Boring Studies. A full-scale investigation in planing was started with the object of establishing relationships of the power demand, feed resistance, quality of finish and cutter wear to the cutting conditions for different classes of timber. Progress has been made on series of tests on kiln-dried beech, using jointed four-knife blocks, with cutting angle from 10°–30°, constant spindle speed of 4,000 r.p.m. and a range of feed speed from 10–120 ft. per min. This work entails careful selection of test material and consistency

in machine performance. For example, control of pressure is important and means of measuring this are under experiment.

Further tests have been undertaken on various classes of timber to determine the power requirements in boring flat-sawn and quarter-sawn material, the suitability of particular types of boring bit for different species and the effect of blunting on power and quality of finish. Preliminary study of the cutting action in boring has been made with the aid of ultra high speed photography.

Woodworking Tests

Major-scale woodworking tests were carried out and reports prepared on the following species :—

Ramin	kiln-dried,	from	Sarawak	
Berlinia	„	„	„	Nigeria
Yellow sterculia	„	„	„	Nigeria
Pterygota	„	„	„	Nigeria
Morabukea	„	„	„	British Guiana
Mora	„	„	„	British Guiana
Greenheart	„	„	„	British Guiana
Muhimbi	„	„	„	Uganda
Japanese larch	„	„	ex Forestry Commission	
Chinese larch	„	„	„	„ „

Nailing tests were made on these timbers and also on Douglas fir and Swedish, Finnish and Polish redwood.

Various studies have been made in staining, spraying and polishing, also on methods of obviating resin exudation, which may occur with certain timbers after finishing.

Advisory Work in Woodworking

Advice has been sought over a wide variety of problems in the wood-using industries, ranging from methods of improving machine performance and overcoming difficulties in working individual timbers to tool design for special purposes. The subject of wood-waste utilization has been raised in many cases, information having been required on the collection and processing of sawdust and wood chips, the manufacture of wood flour, fuel briquettes and charcoal, and the design of furnaces for burning the various forms of waste. Technical enquiries dealt with during the year totalled 274 and advice was obtained by over 100 visitors.

WOOD PRESERVATION

Testing of Wood Preservatives and the Durability of Treated and Untreated Timber

Apart from the normal routine inspections specimens treated with Boliden Salts have been put under test. About a dozen additional species have been added to the tests on natural durability which now total about 250.

These tests on natural durability are continuous as new woods are continually being added, so that, at any one time, there are always many incompleted tests. The results of about 110 completed tests have been analysed and a relationship found between the life of individual samples and the average life of the group. This relationship has been used to forecast the durability of

a species with reasonable accuracy without waiting for all the specimens to decay.

Pressure Impregnation of Timber

Work has continued on the study of the combined effect of temperature and pressure on the impregnation of timber with liquids and on the limiting values before collapse occurs. A successful technique has been developed by which collapse can be studied accurately.

At the request of the Ministry of Supply an investigation has been made on the creosote treatment of Douglas fir structural timbers. British Standard Specification 913 "Pressure Creosoting of Timber" calls for an absorption of 5 lb./cu.ft. for un-incised material of the sizes concerned, but it was found impossible to obtain this absorption in commercial treatments. A number of experimental treatments were carried out at the Laboratory to try to find a suitable treating schedule for such material.

It was found during this work that the high temperature-low pressure schedules recommended and used in the U.S.A. for the treatment of Douglas fir gave very poor results and that better results were obtained when moderate temperatures and higher pressures were employed. At high temperatures and pressures collapse of the type shown in Plate 4 occurs.

Knowledge gained from small-scale experiments on collapse has been of considerable help. Even with the best treating schedule that could be devised using very long pressure periods it was found impossible to obtain consistently a retention of 5 lb./cu.ft., however, and it was clear that the consignment of Douglas fir used for the experiments was abnormally resistant to impregnation.

Two types of Douglas fir are recognized in North West America, namely, the coastal and the mountain-grown varieties, of which only the former can be impregnated to any appreciable depth. Mountain-grown Douglas fir is recognized as being extremely resistant to treatment. It is believed that the material examined was of mountain-grown type but unfortunately no method is known by which coastal and mountain-grown timber can be distinguished from one another. As it is important to establish whether mountain-grown Douglas fir is now being exported from North America, efforts have been made to trace the origin of the material tested but so far without success. If such resistant material could be identified it could be used with advantage for structural work where protection from decay is not necessary and the coastal type used where a good treatment is essential, such as for piling or sleepers. Similar work is now being done on the treatment of western hemlock for heavy constructional work.

Standard Impregnation Tests

During the year standard tests have been carried out on about a dozen new timbers.

Transmission Poles

During the past few years trouble has been experienced with electricity transmission poles developing internal decay after about 14 or 15 years in service. This has been shown to be due to the poles having been badly creosoted, the sapwood being only partly instead of completely penetrated (Plate 5).

As a result of discussions with pole users and the Electrical Research Association, the British Standard Specification for poles has been revised. Greater emphasis has now been put on the necessity for completely penetrating the sapwood and this has meant injecting considerably more creosote into the poles than was formerly done. Since better treatments have been used, however, it has been found that some poles have a tendency to bleed badly when exposed to the sun in summer. This trouble does not appear to occur with poles imported from Norway but is mainly confined to those of Swedish origin. Work is now proceeding to find the reason for this and to evolve a treatment which, while resulting in satisfactory penetration, will also give clean poles.

Preservative Treatment of Plywood

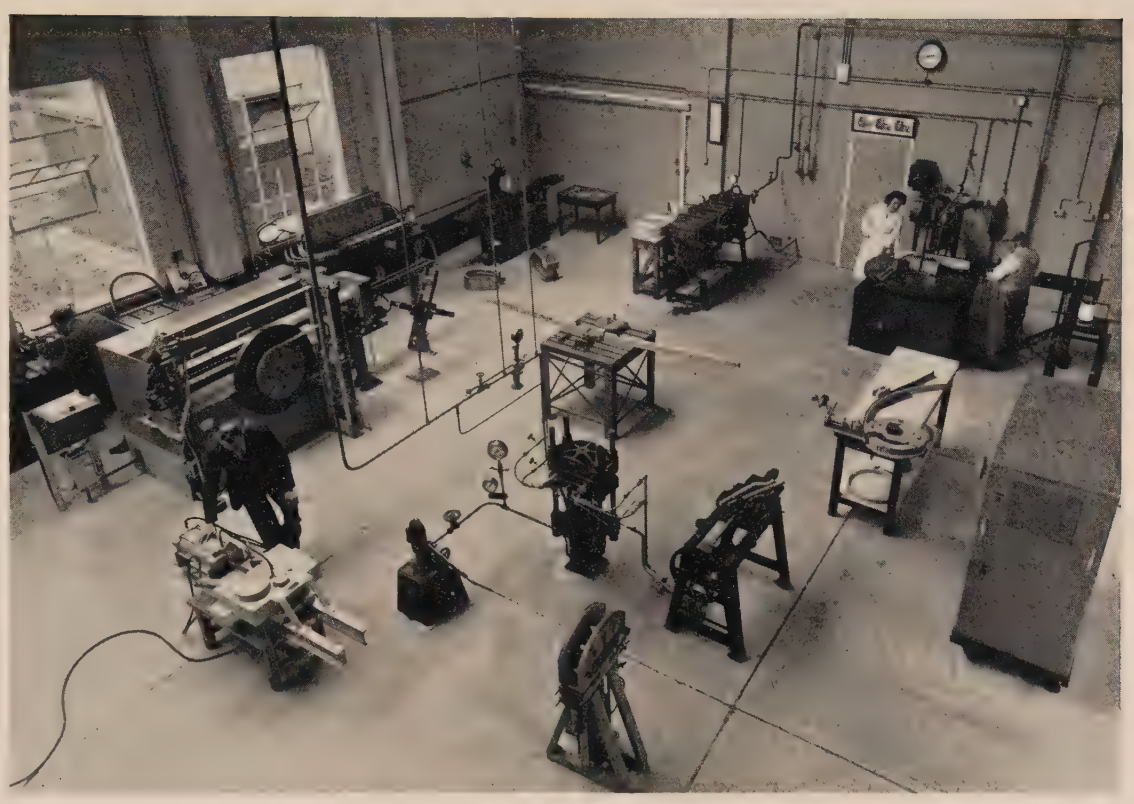
To provide for the needs of the Service Departments, as laid down in forthcoming specifications, the production of preservative-treated plywood has been given high priority, and both methods—treatment of the finished plywood and of its constituent veneers—are under active investigation.

A standard form of test to assess the permeability of various plywoods has shown that those made up of permeable or moderately permeable species can be completely impregnated under pressure even in large sheets. Plywood of resistant timbers, however, cannot be treated through and through and at present a great deal of plywood is being made of resistant species. The fact that such plywood cannot be completely penetrated is often a serious disadvantage as cutting or drilling cannot be done after treatment without having to re-treat exposed untreated wood.

As an alternative to the treatment of finished plywood, investigations are now being made to see if it is practicable to treat the individual veneers before they are glued up. Such treatment can be carried out either with green veneers directly after peeling or later on with dried veneer prior to assembly. At present the most suitable method of treating green veneers appears to be by dipping in a concentrated solution of a water soluble preservative and then close-stacking for a few days to allow the salts to diffuse through the veneers. Dry veneers can be treated by soaking, by the open-tank hot-and-cold method or by pressure. All of these treatments are being investigated and so far promising results have been obtained even with species that are difficult to impregnate when made up into plywood. Preliminary experiments on the production of plywood from treated veneers show that at least some species can be made into reliable $\frac{1}{2}$ in. thick plywood when veneers treated with water-soluble preservatives by the dip and diffusion process are bonded with liquid phenolic glues of the types setting between 100° and 120°C. Some timbers, however, such as Canadian birch present particular difficulties in the gluing operation, and it is not yet possible to generalize on methods of the bonding of preservative-treated veneer.

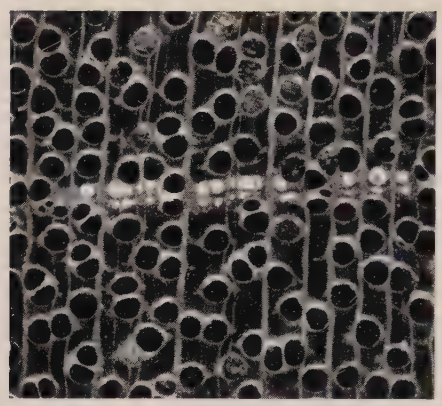
Advisory Work in Wood Preservation

A number of enquiries has been received during the year on the use of timber for the cladding of houses and as shingles. Inspections have revealed that cedar shingles sometimes begin to decay in less than 20 years, and once decay has started it is difficult to treat the wood satisfactorily. It is clear that preservative treatment of these shingles before erection would be well worthwhile.

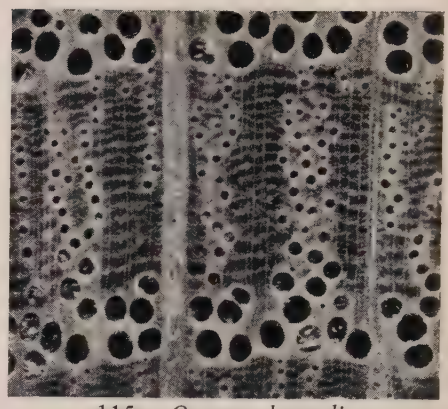


PART OF THE NEW BENDING LABORATORY

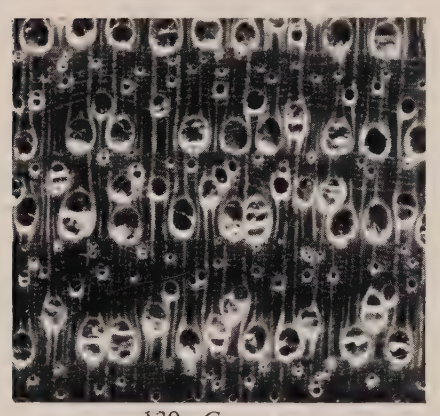
PLATE 1



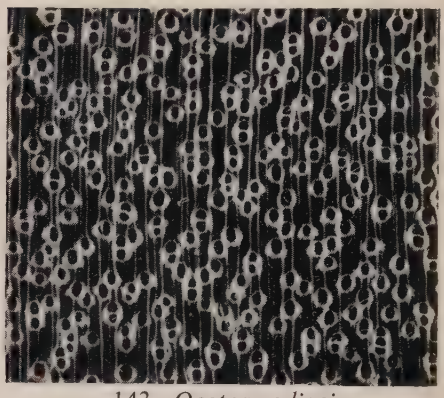
90. *Parashorea malaanonan*
White seraya



115a. *Quercus borealis*
American red oak

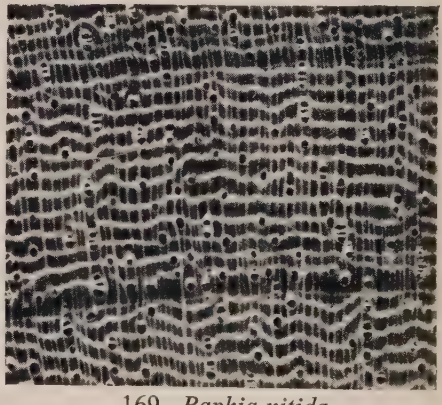


130. *Carya* sp.
Hickory



143. *Ocotea rodiaei*
Greenheart

163. *Albizzia zygia*
Albizzia



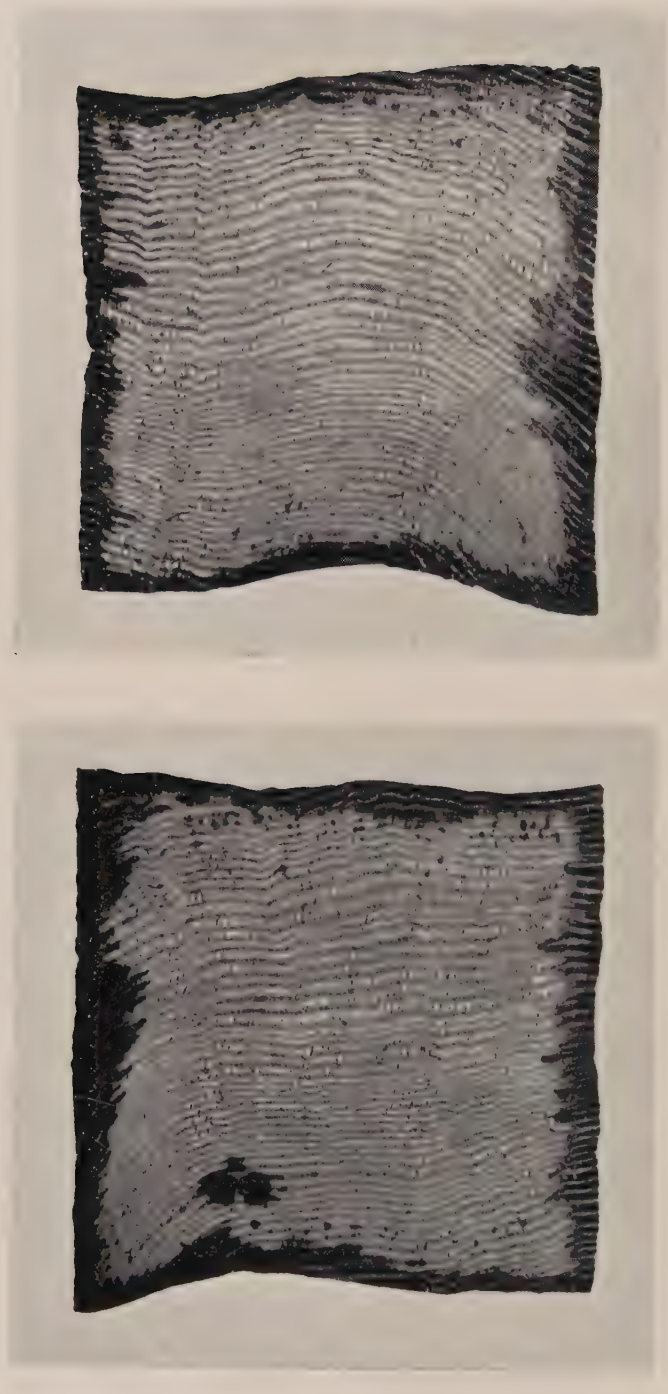
169. *Baphia nitida*
Camwood

A SELECTION OF PHOTOMICROGRAPHS (× 10) FROM "AN ATLAS OF END-GRAIN PHOTOMICROGRAPHS FOR THE IDENTIFICATION OF HARDWOODS"

PLATE 2

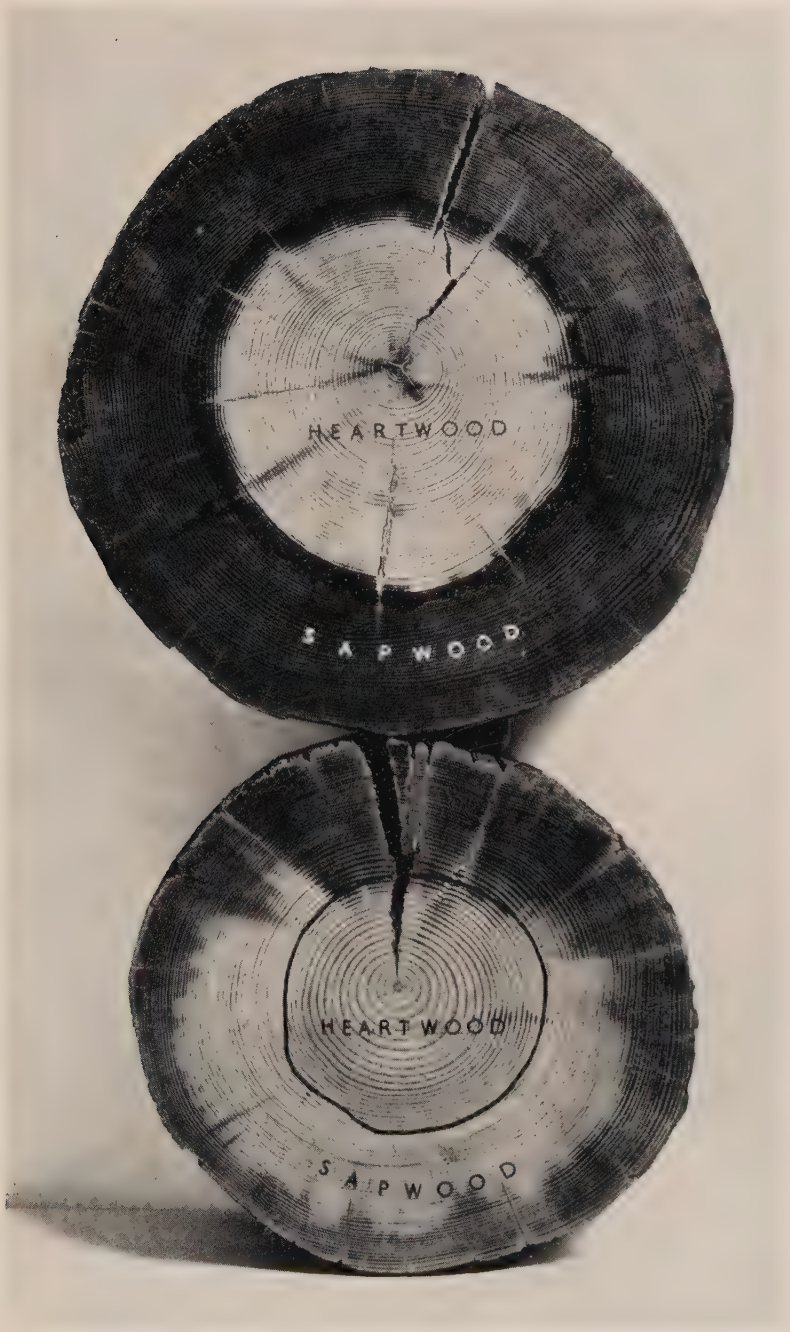
THE PLATEN-OVEN DRYER FOR VENEER SAMPLES

PLATE 3



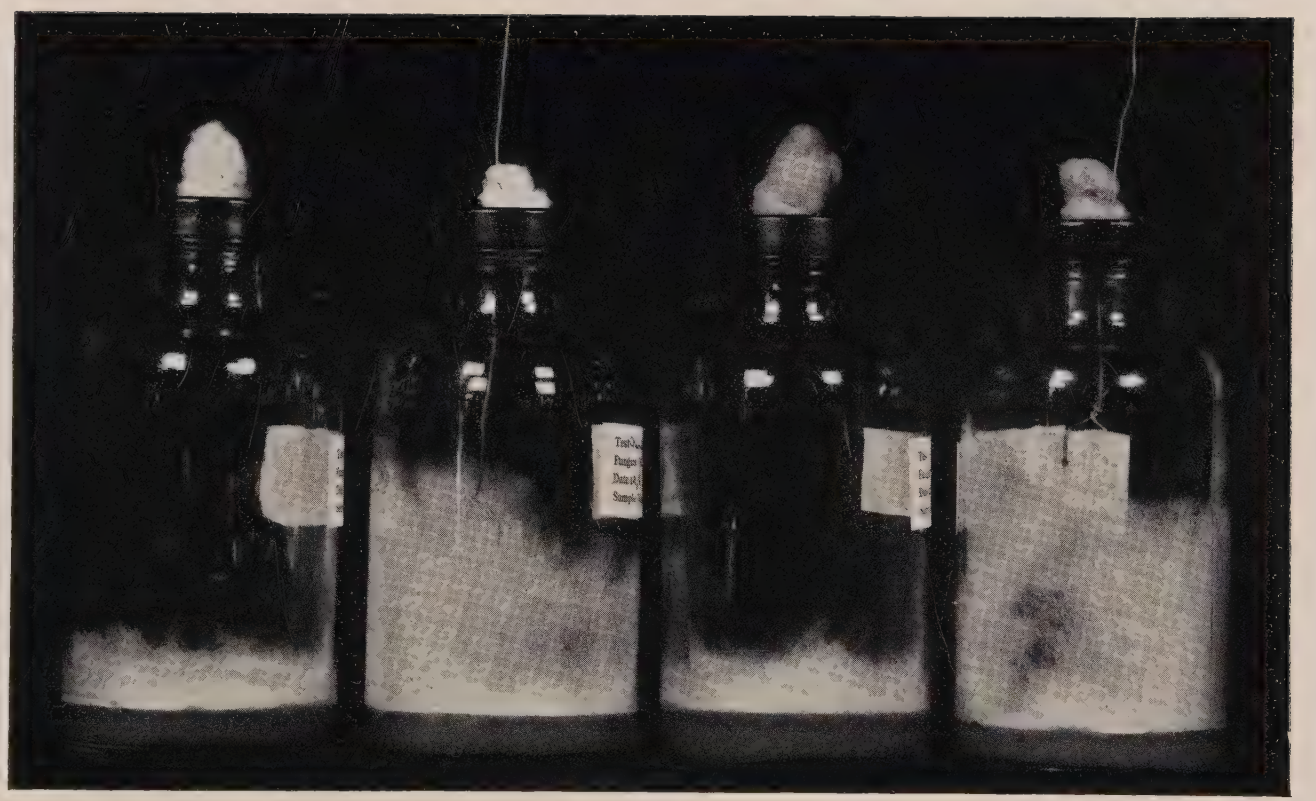
COLLAPSE OF DOUGLAS FIR AT HIGH TEMPERATURE AND PRESSURE DURING PRESERVATION

PLATE 4



CORRECTLY AND INCORRECTLY TREATED TRANSMISSION POLES

PLATE 5



STIMULATION OF FUNGAL GROWTH IN THE PRESENCE OF WOOD BLOCKS

PLATE 6

DAMAGE BY AMBROSIA (PINHOLE BORER) BEETLES IN A TROPICAL HARDWOOD, SHOWING TYPICAL, SHORT, DUST-FREE TUNNELS ACROSS THE GRAIN

PLATE 7

DAMAGE BY AMBROSIA (PINHOLE BORER) BEETLES IN A TROPICAL HARDWOOD, SHOWING ASSOCIATED STREAK OF DISCOLORATION SOMETIMES PRESENT

PLATE 8

Advisory work has continued to be a large item in the Section's work. Besides numerous visitors and telephone enquiries about 500 enquiries have been dealt with by letter.

MYCOLOGY

Collections

The culture collection has been maintained in a good state and eighty-five isolations have been supplied to firms and other research workers. A complete set of all the wood-rotting Basidiomycetes has been sent to the Chemistry Department of Liverpool University for examination by infra-red spectroscopy to detect the presence of metabolic products of special interest.

Cultures of many species of the *Leptoporus* group of *Polyporus* have been presented to the Laboratory by Mr. P. A. Austwick, who has made a special study of this group. These will be of considerable assistance in the identification of fungi of this difficult group which are often isolated from decayed softwoods. Further cultures isolated in Malaya from diseased Hevea trees and stumps have been received and identified.

Standard descriptions of cultures of 124 further wood-rotting fungi in the collection have now been prepared and transferred to perforated cards. Experience in the use of the cards has made it possible to improve the list of diagnostic features.

An important addition to the herbarium was a gift from Dr. G. H. Cunningham, F.R.S., of a collection of specimens of most of the New Zealand Polyporaceae, which will be most useful for the diagnosis of any wood-rotting fungi received from that area.

Physiology of Wood-rotting Fungi

It is evident from the results of experiments carried out at the Laboratory that wood-rotting fungi vary greatly as regards their ability to survive in a viable condition in air-dry wood. Active cultures can still be obtained from samples of wood infected with *Lenzites sepiaria* and *L. trabea* which have been kept for over eight years in a dry atmosphere. *Merulius lacrymans*, the Dry Rot Fungus, on the other hand, has failed to survive seven months' storage in atmospheres of 90, 76, 58 and 44 per cent relative humidities.

The ability of the wood-rotting Ascomycete *Daldinia concentrica* to attack a number of the less durable hardwoods is being investigated.

Stimulation of the growth of wood-rotting fungi when samples of wood are introduced into the culture vessel has often been observed. Preliminary experiments have demonstrated that this stimulation is exerted even if the wood is not in actual contact with the fungus mycelium, thus indicating that it is due to some volatile substance given off by the wood (Plate 6). It remains to be proved whether or not the fungus is stimulated in such a way that its growth is directed towards the source of the volatile compound, i.e. whether a chemotactic effect can direct growing mycelium definitely towards the wood.

A joint paper on the metabolic products of *Polyporus benzoinus*, together with a note on their antibacterial activity, has been published.[1]

[1] Birkinshaw, J. H., Morgan, E. N., and Findlay, W. P. K. Biochemistry of the Wood-rotting Fungi. 7. Metabolic Products of *Polyporus benzoinus* (Wahl.)F. *Biochem. J.*, 1952, **50** (4), 509-517.

Physiology of the "Soft Rot" Fungi

Tests have been undertaken to determine the relationship between loss in strength and percentage weight loss of beech attacked by *Chaetomium globosum*, in comparison with beech similarly attacked by a white rot and a brown rot fungus. The first result obtained from these experiments has been to show that, at least in the early stages, under laboratory conditions beech attacked by *Chaetomium globosum* loses weight as quickly as when attacked by *Coniophora cerebella* or by *Polystictus versicolor*.

The effect of temperature on the rate of growth and rate of breakdown of wood by *Chaetomium globosum* has been studied, and some indication has also been obtained that the rate of attack of beech by *Chaetomium globosum* is proportional to the amount of mineral nutrients which are available to the fungus.

A paper "Breakdown of Timber by Ascomycetes and Fungi Imperfecti with Special Reference to Conditions in Water-cooling Towers" has been prepared for publication.

Laboratory Tests on Wood Preservatives

Toxicity tests on proprietary wood preservatives continue to be carried out on request, and a number of standard wood block tests have been made on preservatives that incorporate pentachlorphenol.

Agar and wood block tests on sodium fluoride-calcium chloride mixtures indicate that when sodium fluoride is thoroughly mixed with soluble calcium salts it becomes inactivated as a wood preservative. In view of these results it would seem better not to rely on pure sodium fluoride as a preservative for timber, e.g. laths, which is likely to come into direct contact with materials such as fresh lime plaster.

Agar and wood block tests on the toxicity of several water-soluble preservatives to *Chaetomium globosum* have been made.

Sap-stain Investigations

Laboratory tests have been carried out to determine the efficacy as sap-stain preventives of a number of organic compounds of a type not hitherto used for this purpose. Large-scale tests were also made on these compounds, using 5 ft. long boards of Scots pine sapwood as test timber.

The toxicity to sap-stain fungi of several organic tin compounds submitted by the Tin Research Institute has been examined by agar tests and found to be exceptionally high.

Enquiries have been received regarding the control of mould growth on the chip baskets used by the soft fruit industry. The choice of preservatives for this purpose is somewhat limited as the fruit makes direct contact with the treated timber. Tests with one proprietary preservative have already been carried out and tests of other suitable materials are contemplated as soon as they become available. The allied problem of fungicidal treatments for fruit boxes for apple storage has been dicussed with Dr. Tomkins of the Ditton Laboratory and a programme of work is under consideration.

Fungal staining and, to a lesser extent, decay of light hardwoods imported from the tropics continue to be a problem. The matter has been discussed with some of the importers and preservative treatment of the logs has been suggested.

A cargo of treated ramin timber inspected as it was being unloaded at the docks was found to be in excellent condition.

Fungi isolated from stained samples of light-coloured tropical hardwoods have generally proved to be species of *Diplodia* and an effort is being made to find out what the species are. The effect of temperature on the rate of growth of these fungi is being measured and the lethal temperatures required to sterilize wood infected with *Diplodia* will be determined.

Laboratory Tests on Natural Durability of Timbers

Standard laboratory tests on the resistance to decay of the following timbers have been completed: andiroba, Bermuda cedar, cherry, *Eucalyptus saligna* (from South Africa), krabak, kurokai, pear, red sterculia, Japanese larch, sweet chestnut, walnut and wamara. The sample of cherry tested proved to have an unexpectedly high resistance to attack and it is planned to test samples from another tree.

The influence of the size of samples upon their rate of decay in culture has been studied. It was found that over a given period the loss in dry weight of small thin samples is considerably greater than of larger samples. A paper describing these results has been submitted for publication in " Forestry ".

The toxicity to fungi of further samples of extractives prepared by Professor King at Nottingham University has been tested.

Tests on the Resistance of Composite Materials to Fungi

At the request of the British Standards Institution a draft specification has been prepared for methods of test of the resistance of composite building materials to decay and mould attack. The test against wood-rotting fungi is based on the standard wood block preservative test. Preliminary work on methods of testing resistance to mould attack has indicated that a satisfactory degree of attack can be obtained on susceptible materials by exposing them over water in a sealed desiccator.

Tests of a chipboard and two preservative-treated fibreboards have been carried out.

Laboratory tests of gaboon plywood in which the veneers had been impregnated with a synthetic resin have shown this material to be highly resistant to fungal decay.

Tests of the rot resistance of eighteen types of fire hose for the Fire Research Organization have been completed. A similar series of tests on fifteen types of conveyor belting has been carried out for the National Coal Board. It has been concluded that the heavy rubber or plastic covering of the conveyor belting provides much mechanical protection against fungal attack. This is in agreement with observations made by the National Coal Board in the field, which suggests that rapid deterioration occurs only when badly worn conveyor belting is stored.

Dry Rot Investigations

A paper prepared in co-operation with the Building Research Station on the use of zinc oxychloride paints and plasters in the eradication of *Merulius lacrymans* from infected masonry has aroused considerable interest. A visit was

made to a school at Lancaster where large-scale application of the plaster was contemplated.

The ingredients for the oxychloride mixtures are not readily available commercially and it is unlikely that they can be widely used in the immediate future. The requirements of the building trade would best be satisfied by the provision of antiseptic materials which could be mixed into ordinary cement rendering With the active co-operation of the Building Research Station search for such materials continues. A preliminary test of cement renderings containing copper aceto-arsenite has shown that ordinary cement can be made toxic to fungi, but no further work with this particular chemical will be carried out as its use might involve a risk to health.

A new (5th) edition of the Bulletin " Dry Rot in Wood " has been prepared and published by H.M. Stationery Office.

Breakdown of Timber in Water-cooling Towers

At the beginning of the year the British Electricity Authority appointed a research worker to investigate the mycological problems involved in deterioration of timber in water-cooling towers. This worker spent five months at the Laboratory studying the techniques used and collaborating in the research work in progress on this problem.

Water-cooling towers at Kettering power station were inspected in company with representatives of the British Electricity Authority. For the first time in this country, decay caused by Basidiomycetes was discovered in the filling timbers. Serious decay of the structural timbers of the towers was also noted. The presence of the Basidiomycete attack in the slats is believed to be a result of drier conditions arising from the infrequent use of these towers in the past few years. The usual Ascomycete attack was also present.

Isolation of fungi from timber showing attack similar to that found in water-cooling towers continue to be made. The term " soft rot " has been coined to describe this type of fungal attack.

Discussions have been held with the British Electricity Authority and the Timber Development Association regarding the advisability of using hardwoods for filling in water-cooling towers. Laboratory tests have been carried out to ascertain the suitability of selecting hardwoods by exposing them to attack by *Chaetomium globosum* both untreated and after leaching them with warm water for periods of up to 8 weeks. Opepe, greenheart and wallaba were not attacked but wallaba exuded an extremely sticky gum on being leached and is therefore not considered suitable for use in cooling towers. Tallowwood both leached and unleached suffered only slight losses in weight, which were confirmed by microscopic examination as being due to fungal attack. Nyankom and beech showed marked decay. Greater losses were obtained in leached than in unleached beech.

Samples of a resin-bonded gaboon plywood in which the veneers themselves had been impregnated with a synthetic resin, exposed to similar treatments, showed only low weight losses and slight visible evidence of the attack of *Chaetomium* sp. This was in marked contrast to severe attack in ordinary gaboon plywood controls bonded with the same adhesive. The results obtained with this material support the view that impregnation of the surface of the wood with suitable water-resistant materials might give an improved service life for cooling-tower filling timbers.

Decay of Timber in Boats

In view of the apparent seriousness of decay in wooden boats, a meeting was convened of representatives from the Services, boatbuilders, naval architects and fishing interests to discuss the problem. Arising from that meeting, work has begun on the preparation of a Bulletin and a Leaflet dealing with this subject. In the course of collecting information, visits have been made to Rosyth to inspect naval craft there and also to Aberdeen to inspect fishing boats in that area. There is striking contrast between fishing boats and pleasure craft in that decay does not appear to present a serious problem in the former. The vital difference between fishing boats and pleasure boats appears to lie in the relative periods during which the two types of craft are in active use each year. It would seem that to use a wooden boat at infrequent intervals increases the risk of decay of the timber more than has been previously realized, and it appears that for satisfactory control of decay in pleasure craft there must be a marked improvement upon traditional construction methods by the use of more durable timbers or of modern methods of wood preservation.

At the suggestion of H.R.H. the Duke of Edinburgh an inspection of the "*Cutty Sark*" was carried out. The boat showed little evidence of fungal decay, which is noteworthy in a vessel which is over 80 years of age and has been laid up for considerable periods. The absence of fungal decay can be attributed to the extensive use of teak in construction.

A lecture has been given at H.M.S. *Hornet* on decay in wooden boats and instruction on this subject has been given to two shipwright officers who visited the Laboratory.

Samples of gaboon plywood and solid makoré which had been exposed in the sea for one year were found to show attack similar to that found in water-cooling towers. The marine fungus *Helicoma maritimum*, previously recorded by Baghoorn and Linder as causing decay of wood blocks immersed in the sea, was isolated from these timbers.

It has become obvious that many instances of soft rot (see page 32) occur in wooden boats and in other timber structures immersed in sea or fresh water but it is usually not of great importance. In two instances in which its presence was causing concern it was noted that timber adjacent to the decayed area had been protected from attack by the marine anti-fouling paint.

Advisory Work in Mycology

The number of advisory enquiries again showed an increase over the previous year. Just over 1,100 enquiries were dealt with by letter and many others by personal visits from the enquiriers.

In addition to the usual number of enquiries about decay of timber in buildings, many requests for advice about treatment and prevention of decay in boats have been received. An increasing number of enquiries have referred to staining and decay in imported hardwoods and to the possibility of utilizing such defective material.

A number of inspections, both of buildings infected with dry rot and of defective shipments of timber, were made.

Among the miscellaneous enquiries received, the following may be quoted as being of unusual interest:

A growth of *Merulius lacrymans* in a church which penetrated into the organ pipes and encrusted the stops, thus interfering with the electrical action; the storage of large volumes of *Eucalyptus saligna* pulpwood; premature decay in cedar shingle roofs; heavy growths of mould on walls of a bonded liquor store; use of sawdust as mulch and in composts.

ENTOMOLOGY

Lyctus *Powder-post Beetles*

Investigations on Treatment of Timber in Stick. Examination has been completed of the experimental piles of oak that had been sawn through-and-through, and treated in May 1951 and subsequently exposed to attack by *Lyctus brunneus*. The treatment consisted of a 5 per cent D.D.T. emulsion in water, or a 1 per cent gamma isomer of benzene hexachloride made up from a water-dispersible powder, applied in the form of a spray by a commercial type of insecticidal fog applicator. The results confirm previous indications that this type of treatment is insufficient to prevent attack in parts of the pile furthest from the point of application. Similar results were obtained with D.D.T. applied as a spray to a stack of square-edged timber, the treatment being insufficient to protect the inner boards. Past work on the prevention of *Lyctus* attack in through-and-through sawn logs of English oak stored as boards has been confined mainly to D.D.T. preparations, but during the summer of 1952, a new series of tests was set up using two formulations of benzene hexachloride at varying concentrations and subsequently exposing the treated timber to infestation by *Lyctus*.

The Laboratory's recommendations (Leaflet No. 43) for D.D.T. spray treatment during the spring to prevent *Lyctus* attack on timber storage premises have been adopted by Timber Control London area. Opportunity was taken of observing these treatments—usually in the hands of pest control operators—and of supplementing information on the problems involved, e.g. quantity of insecticide used in relation to coverage of timber.

Protection of Plywood. An investigation to determine the value of the addition of D.D.T. to a phenol-formaldehyde adhesive for the prevention of attack by *Lyctus* was referred to in some detail in the last Report. This was undertaken in co-operation with a firm manufacturing plywood in West Africa and has now been completed[1]. It has been shown that the presence in the glue-line of 2 per cent technical grade D.D.T. (75-80 per cent para-para isomer) will prevent infestation in 3-ply obeche (1·6 mm × 3·2 mm × 1·6 mm) when exposed to attack two months after manufacture: the full period of protection afforded has not, however, been determined.

Heat Sterilization Treatments. Forest Products Research Leaflet No. 13 on heat sterilization of *Lyctus*-infested timber has been revised. Schedules now recommended provide for the possibility of variations in temperature and humidity in different parts of a kiln in order to reduce the risk of lethal conditions not being obtained throughout.

Little information has hitherto been available on the application of sterilization schedules recommended for *Lyctus*-infested timber for use against other

[1] TAYLOR, J. M. and FISHER, R. C. Protection of Obeche Plywood from Infestation by *Lyctus* Powder-post Beetles: Effect of the Addition of D.D.T. to P.F. Adhesive. *F.P.R.L. Neostyled Report*, 1952.

wood-boring insects. Recent importations of timber infested by Bostrychid powder-post beetles have raised the need for more accurate data on this subject. A series of experiments has therefore been undertaken with ramin containing living larvae and beetles of *Heterobostrychus aequalis*, a common species in the Indo-Malayan region. Shortage of material restricted the tests, but results show that the 130°F schedule is lethal, giving 100 per cent kill, but that at 125°F the treatment is not completely effective. Extension of this work is contemplated when further material infested by Bostrychid or other wood-boring insects becomes available.

The Common Furniture Beetle (Anobium punctatum)

General biological work has been continued with particular reference to the condition in timber suitable for larval development. Previous indications of the favourable effect of decay in wood on the growth of the larvae have been confirmed, but there are several aspects of the relationship between fungi in wood and infestation by this insect which require elucidation. A progress report on the information so far obtained is in the press [1]. Experiments have now been started to determine the effect of a range of moisture contents of decayed wood, including fluctuating conditions of temperature and humidity, on the rate of larval growth. Little information is as yet available on the conditions in sound timber, e.g. age, that determine its suitability for attack. A new approach to this problem has been made by removal of water- and ether-soluble extractives from the sapwood of fresh, unseasoned Corsican pine before exposure to infestation. Differences, suggested by recent German work, in the susceptibility of sapwood in relation to its position in the tree are also being investigated. Chemical analyses indicate that in the above species there is a slightly decreasing gradient in nitrogen content from the periphery towards the pith, but that the resin distribution appears to be fairly uniform. A comparison is also being made of the susceptibility of kiln- and air-dried timber to attack by this insect.

These biological investigations have involved continued studies of the egg-laying potential of the beetle by dissections of males and females. In the course of this work a comparison has been made with the morphology of the death-watch beetle. Further work on the duration of emergence of *Anobium* and on the incubation period of the egg has been carried out to amplify earlier data. A note on the sex characters of the pupae has been published[2].

In view of the lack of experimental data on the toxicity of hydrocyanic acid to the eggs of the common furniture beetle, a special investigation has been carried out in co-operation with the Pest Infestation Laboratory. Larvae were included in the experiment for comparison and the results show that eggs are considerably more sensitive, a much lower time-concentration treatment being required for their destruction than for larvae. An account of this work is being prepared for publication.

The House Longhorn Beetle (Hylotrupes bajulus)

Investigations on this insect during the year have included survey work by inspections of buildings in new localities in which infestation has been reported,

[1] BLETCHLY, J. D. The Influence of Decay in Timber on Susceptibility to Attack by the Common Furniture Beetle, *Anobium punctatum* De G. *Proc. Ass. appl. Biol.*: *Ann. appl. Biol.*, 40 (*In the press*).

[2] BLETCHLY, J. D. A Note on the Pre-pupal Stage and the External Sex Characters of the Pupae of *Anobium punctatum* De G. *Bull. ent. Res.*, 1953, **43** (4), 587-590.

and general biological studies. Survey records have confirmed that instances of old attack may occur in widely separated localities in the southern part of England and that active infestation is still largely confined to the Surrey area, particularly in pine country, with which a close association has been suspected. Confirmation of this has been obtained by the discovery of the insect in the dead top of one of a number of Douglas firs in a playing field within an infested area: it has also been found in softwood building timbers stored on a timber merchant's premises in the same district. There is now little doubt that infestation of roofing timbers in buildings in certain districts of Surrey is associated with the breeding of the insect in its natural habitat, i.e. in dead parts of standing trees or in fence posts and other softwood timbers out-of-doors.

With the co-operation of a local authority, records are being obtained of conditions of temperature and humidity in the roofs of buildings in districts in which infestation is most frequent. Opportunity has been taken in the course of inspections to collect data on results of control measures, which have been summarized in a new edition of the Laboratory's Leaflet (No. 14) on this insect.

Studies have been continued on the behaviour of the beetles, their emergence, egg-laying and duration of life under different conditions, and observations have been made on the habits of the first-stage larvae. The results of infestation experiments started during summer 1951 have shown a marked difference in rate of growth of larvae and extent of damage in pine sapwood according to temperature and humidity, development being most rapid at 25°C and 70 per cent relative humidity. Investigations on the nutritional value of sapwood in relation to its position in the tree, comparable to similar work with the common furniture beetle, have also been started during the past summer.

Laboratory Tests with Insecticides

The work on the use of insecticidal smokes for the destruction of wood-boring insects after emergence in a building and for prevention of spread of infestation has been continued. Experiments with D.D.T./Lindane (gamma isomer of benzene hexachloride [BHC]) smoke generators have been carried out in a room of 650 cu. ft. capacity. Chemical estimation of the insecticidal deposits obtained on filter papers placed in different positions throughout the room showed variations, according to dosage, from 8·5-70 mg/sq. ft. on upper horizontal surfaces to 2·73 mg/sq. ft. on under surfaces. *Lyctus* beetles confined for 24 hours on upper horizontal surfaces with the above deposits were rapidly affected and egg-laying prevented. The smaller deposits on the under surfaces were insufficient to affect the beetles or prevent egg-laying. Results with this proprietary mixture of D.D.T. and BHC are similar to those obtained in earlier experiments, in which each type of insecticidal smoke was tested separately. The principal value of such treatments is destruction of beetles after they have emerged from infested wood and are present in a room, roof or other space at the time of liberation of the smoke. Prevention of spread of attack through contact with a residual deposit is restricted by its presence in toxic amounts to upper horizontal surfaces and, to a lesser extent, vertical surfaces. The duration of toxicity of such deposits has not been determined.

In connexion with evaluation of wood preservatives and insecticides exploratory work has been undertaken to investigate the larval transfer technique with first-stage larvae of the house longhorn beetle and larvae of varying size of the common furniture beetle. This technique has been used extensively in

Germany but in other countries has not been accepted as satisfactory. The results so far obtained at this Laboratory suggest that, apart from the suitability of the wood for normal development—the first essential—size of transferred larvae, particularly of the common furniture beetle, is an important limiting factor for their successful establishment. Results have, however, been promising and work is continuing.

A brief investigation has been carried out with an insecticidal mixture brought to the notice of the Laboratory as an alternative to more expensive proprietary preparations for the eradication and prevention of attack by wood-boring insects. Results have shown that the preparation did not fulfil its claims.

Insect Damage in Imported Timbers

Investigations on Timber Insects in West Africa. Attention was drawn in the last Report to the prevalence of damage (Plate 7) by ambrosia (pinhole borer) beetles of the families Platypodidae and Scolytidae in tropical hard-woods, and to the need for investigations in the countries of origin of the timbers. The Laboratory's memorandum submitted to the Colonial Research Council outlining the problems involved, and including a programme of research, has been welcomed and approved by the Governments of the Gold Coast and Nigeria and has led to the appointment by the Colonial Office of three biologists to form a West African Timber Insect Research Unit. The Laboratory has been asked to undertake the specialized training of this team and to supervise and collate its work. In due course, two officers will go to West Africa, the third remaining at Princes Risborough to study the relationships between the insects and the ambrosia fungi with which they are associated. This is essential for the understanding of the conditions which govern infestation and for the development of improved means of preventing attack by these insects. It is gratifying to be able to record that a start has been made in West Africa on research on this problem, to which the Laboratory first drew attention in 1936[1]. The utilization of many new tropical timbers now makes a study of the problem increasingly urgent and a paper prepared in collaboration with the Entomologist, Imperial Forestry Institute, Oxford, summarising existing information on ambrosia beetles and their control, was presented for discussion at the Commonwealth Forestry Conference, Canada, 1952[2].

Advisory Work in Entomology

Advisory work has continued to make large demands on the time of the Section throughout the year and 1,336 enquiries have been dealt with by letter. Whilst most of this correspondence has concerned firms and private individuals in this country, an increasing number of enquiries from overseas has been dealt with requesting information on more general problems in which timber insects are involved. The following are examples:

(a) Forest Research Institute, Kepong, Malaya. Comments requested on proposed layout of series of resistance tests of Malayan timbers to attack by powder-post beetles.

[1] FISHER, R. C. The Need for Forest Entomologists with Special Reference to the Pinhole Borer Problem. *Emp. For. J.*, 1936, **15** (2), 201-209.

[2] FISHER, R. C. and THOMPSON, G. H. Recent Developments in the Prevention of Attack by Ambrosia (Pinhole Borer) Beetles in Standing Trees and Logs. *6th British Commonwealth Forestry Conference, Canada*, August, 1952.

(b) East African Trade Commission. Information on prevention and control of insects affecting timber in East Africa.

(c) Various institutions in New Zealand and Australia. Information on pretreatment of building timbers for prevention of infestation by *Lyctus* and the common furniture beetles.

(d) Commissioner of Works, Northern Rhodesia. Information on house longhorn beetle and preventive treatment arising out of possible introduction of the insect in softwood timbers *via* South African ports.

As in past years, the common furniture beetle has again been responsible for about one-third of the advisory correspondence, the remainder concerning powder-post, longhorn, death-watch beetles and wood-boring weevils of the family Cossonidae. Of particular interest are a few instances of the occurrence of damage by a European forest insect, *Serropalpus barbatus* (family Melandriidae), in Yugoslavian whitewood. The presence of this beetle or its larvae has been noted in building timber, either during or shortly after installation. It is unimportant as a pest of seasoned timber and is not a native of this country; the damage it causes closely resembles, and may in the past have been confused with, the type of defect caused in softwoods by the better known *Sirex* woodwasps.

The occurrence of large numbers of flour beetles (*Tribolium* spp.), from the holds of ships and barges, on the surface of timber in storage premises has led to confusion with *Lyctus* beetles to which they have a superficial similarity, and has caused timber importers and merchants unnecessary concern. In reponse to requests, an illustrated note[1] has been prepared to enable the two insects readily to be distinguished by the aid of a low-power hand lens.

Inspections. It has again been necessary to reduce the number of inspections on a fee basis carried out on request, 13 inspections having been made as compared with 20 last year. At the suggestion of H.R.H. the Duke of Edinburgh an examination of the " *Cutty Sark* " was undertaken to advise on the preservation of her timbers.

CHEMISTRY

A series of simple chemical tests are now applied to all new timbers coming into the Laboratory for general testing. These will give information supplementary to that provided by other sections, bearing on the suitability of the timbers for specific uses. The properties examined include tainting and staining characteristics, liability of the timber to discolour when in contact with iron compounds, tendency to promote corrosion of metallic fittings, and presence of resins or gums, or of silica, which may influence the sawing properties of the timber.

Research on Wood Analysis

The work already reported on the delignification of wood with sodium chlorite solution, leading to the recognition of the presence in wood of an acid-

[1] HARRIS, E. C. Powder-post Beetles (*Lyctus*) and Flour Beetles (*Tribolium*). Distinguishing Features. F.P.R.L. Neostyled Note, 1952.

soluble form of lignin, has now been published in two papers[1, 2]. A third paper [3] describes the preparation of a hemicellulose fraction from beech wood in a fairly pure condition. A large sample of this material has been sent to Professor E. L. Hirst at the University of Edinburgh for investigations on its constitution. It is proposed to extend this work by attempting to isolate and purify the remaining hemicelluloses present in beech wood.

Acid-soluble lignin can be isolated from the hydrolysate obtained by treating wood with 72 per cent sulphuric acid to remove the acid-insoluble lignin. If wood that has been partially delignified with sodium chlorite is used, a product termed " modified lignin " is obtained. This contains chlorine, derived from the sodium chlorite, and is therefore believed to have been modified by the chlorite treatment so that it is no longer isolated as an insoluble residue by the sulphuric acid method.

The relationship between acid-soluble lignin and modified lignin has been examined further, particularly in regard to their ultra-violet absorption spectra. It is found that, both for beech and spruce lignins, there is very little difference between the absorption spectrum of the acid-soluble and of the modified lignin. This suggests that the main conjugating system is the same in the two products, and is little affected by the addition of Cl_2 or HCl in the modified lignins.

Attention is now being directed to the carbohydrate portion of wood, and arrangements are being made to employ the method of partition chromatography on paper in the examination of the sugars formed by hydrolysis of the various polysaccharide fractions of the wood cell wall. This technique has achieved great prominence in recent years, and in the hands of Professor E. L. Hirst, Dr. J. K. N. Jones, and others it has led to important advances in the field of carbohydrate chemistry. It is known that when extractive-free wood is treated with cold aqueous sodium hydroxide only a portion of the hemicelluloses present in the wood is extracted by the alkali, and a method has previously been reported whereby this fraction of the hemicelluloses can be isolated in a fairly pure condition. The remainder of the hemicelluloses can only be extracted by sodium hydroxide if the wood is first delignified, suggesting that this fraction may be combined in some way with the lignin, or may be inaccessible to the alkaline reagent on account of the presence of lignin in the cell wall. It is of interest to know whether or not this fraction of the hemicelluloses differs chemically from the fraction which can be extracted directly. Steps are being taken to isolate both materials and examine them by chromatographic methods, after hydrolysis, to find the nature and proportions of the sugar units of which they are built up. It has already been shown that the amounts of free sugars (glucose and fructose) present in beech wood are very small.

Wood Starches. Qualitative tests had indicated that the sapwood of the Australian tree *Eucalyptus obliqua* possessed an unusually high starch content,

[1] Campbell, W. G. and McDonald, I. R. C. The Chemistry of the Wood Cell Wall. Part I. The Delignification of Beech and Spruce Woods by Sodium Chlorite in Buffered Aqueous Solution. *J. chem. Soc.*, **1952**, 2644-2650.

[2] Campbell, W. G. and McDonald, I. R. C. The Chemistry of the Wood Cell Wall. Part II. The Isolation of Beech and Spruce Acid-soluble and Modified Lignins. *J. chem. Soc.*, **1952**, 3180-3183.

[3] McDonald, I. R. C. The Chemistry of the Wood Cell Wall. Part III. The Isolation of Beech Hemicellulose A. *J. chem. Soc.*, **1952**, 3183-3186.

and the isolation of the starch for constitutional studies was therefore undertaken.

The method used was a modification of that employed in the preparation of starch from elm sapwood.[1] The starch grains present in this wood appeared to be larger than those previously obtained from other sources (oak, elm, maple), and stirring with water appeared to swell the grains appreciably, as well as to produce undesirable fragments of wood which were difficult to separate from the starch itself. The technique of shaking the grains out in ether was therefore adopted. Portions of the wood were shaken with ether in stoppered Winchesters at room temperature for several hours, the supernatant liquid was removed and the residue shaken with a fresh quantity of ether as before. The starch suspension so obtained was combined with the first and the solid material allowed to separate by sedimentation. The supernatant liquor was then used for the extraction of a further batch of sawdust under the same conditions. 3·5 kg of wood were treated in this manner, and the combined products fractionated by sedimentation. The solvent was then changed successively to alcohol, water, water-acetone (50:50), and acetone, fractionation being effected in each. This process removed much of the colour from the product. The solid material was removed at the centrifuge, washed with methanol and ethyl acetate and dried in a vacuum desiccator over calcium chloride. Yield, ca 0·3 per cent. This granular starch has been sent to Professor E. L. Hirst for further investigation.

Production of Fibreboards from Secondary Colonial Timbers

Further experiments have been carried out with wallaba in order to determine the optimum conditions under which boards can be made to meet the requirements of British Standard Specification 1142 (Draft Revision CM(TIB) 8131). These experiments form part of an integrated scheme for the utilization of both fibre and extractives from this timber.

A method of extraction with alcohol vapour has been applied which has effected virtually complete removal of all the alcohol-soluble material from full size cooking chips in a short time. The apparatus is simple and should be equally efficient on a large scale. Boards of high strength (10,000—11,000 lb./sq. in. modulus of rupture) have been made from the extracted chips, but their water absorption is considerably higher than that of boards made from unextracted wood. It has been found possible to make good the loss of water repellence owing to complete removal of the wallaba " gum " by small additions of rosin size to the pulp. Boards having water absorption values low enough to comply with the requirements of the draft revision of B.S.S. 1142 have also been made by incorporating small quantities of wax emulsions. Both methods of sizing give rise to slight loss of strength but boards so treated have still retained a substantial margin over the specified minimum value for modulus of rupture. A series of experiments has been carried out to investigate the value of prolonged heat treatment applied to boards after pressing as an alternative to sizing. Considerable improvement has been effected, by this means, in the water resistance of unsized boards without loss in strength properties, but so far the wax emulsion treatment has proved more reliable.

Board-making trials have also been undertaken on morabukea. Although

[1] CAMBELL, W. G., FRAHN, J. L., HIRST, E. L., PACKMAN, D. F., and PERCIVAL, E. G. V. Wood Starches. *J. chem. Soc.*, **1951**, 3489-3498.

hard and of high density (60-65 lb./cu. ft.) this timber has yielded satisfactory pulping chips in the experimental chipper, best results being obtained with the wood at a moisture content of not less than 35-45 per cent. Boards of satisfactory strength (8,000—10,000 lb./sq. in. modulus of rupture) and of pleasing appearance have been made using a cooking schedule similar to that previously reported for wallaba. Water absorption values for these boards were as high as and, in some cases, higher than those for extracted wallaba. It was possible, however, with small additions of a proprietary wax emulsion size to produce boards which met specified requirements for standard hardboard in all respects. Similar results to those reported for wallaba were obtained with heat-treated boards.

A further series of experiments has been carried out in order to determine the practical lower limit of chemical consumption required to make boards with strength properties meeting the specification. Using morabukea chips, satisfactory results have been obtained with a consumption of 5 per cent of sodium sulphite and 2·5 per cent sodium bicarbonate (based on the dry weight of wood cooked). A cooking time of one hour at a temperature of 180°C. has proved to be sufficient with these quantities and pressures of approximately 200 lb./sq. in. have been maintained in the digester owing to the combined effect of steam and carbon dioxide produced in the course of the reaction. Boards made from pulps cooked with less than 5·0 per cent of sodium sulphite have not been sufficiently strong even when the pH of cooking liquors was kept up by small additions of other alkalis. Results of similar tests with wallaba so far completed suggest that the limits in this case will be of the same order.

Steps are being taken to obtain a disc mill for defibering the cooked chips in place of the beater at present in use. It is thought that this will be more efficient and it may enable the consumption of chemicals to be still further reduced. As the difficulties in the way of manufacture of fibre-boards from secondary tropical hardwoods are likely to be mainly economic it is of great importance to take all possible steps to reduce operating costs.

Extractives of Toporite (Hernandia sonora)

Dust from the Trinidad timber toporite is alleged to cause skin irritation and dermatitis among workers in sawmills. This timber has therefore been investigated in order to discover whether any toxic materials, in particular alkaloids, are present. It is known that the bark of the tree contains alkaloids belonging to the bebeerin family. During the course of this investigation it became known that work on similar lines was in progress at Nottingham University under the direction of Professor F. E. King.

The wood available had a light-coloured sapwood and a dark brown heartwood, which were examined separately. The extracts with ether and alcohol were resolved into a series of fractions as follows:

Treatment of the sapwood with ether extracted about 3 per cent by weight of the wood. On evaporation of the ethereal solution colourless crystals, melting point 200-203°C, separated in 0·3 per cent yield. This material was soluble in benzene and chloroform, and sparingly soluble in ether and alcohol, and insoluble in water. It has been shown by Professor King to consist of a mixture of the acetates of the isomeric substances picropodophyllin and podophyllotoxin. This was confirmed by analysis, and the mixture was separated by several recrystallisations into picropodophyllin acetate, melting

point 216°C, $[\alpha]_D$ + 60.6° in chloroform, and podophyllotoxin acetate, melting point 204°C, $[\alpha]_D$ —110·3°.

The remainder of the ether extract was a dark brown resinous material, in which no alkaloids could be detected. If, however, the sapwood is first steeped in ammonia and then extracted with ether the resulting solution gives on evaporation a dark brown resin which gives positive reactions with the usual alkaloid reagents.

By extracting the ether-extracted sapwood with boiling alcohol by a counter-current method a further 2 per cent by weight of the wood was extracted. Evaporation of the alcoholic solution under reduced pressure yielded insoluble material amounting to 17 per cent of the total extract, of which 20 per cent was mineral matter. Precipitation of the concentrated extract with 10 times its volume of ether gave a brown ligneous material, which gave a positive Mäule reaction. After concentration the filtrate was poured into water. The sticky resinous material was separated, the aqueous solution concentrated *in vacuo* at 50°, and extracted repeatedly with chloroform. The chloroform solution yielded on evaporation a further quantity of a bright red resinous material, and the final aqueous solution, evaporated and dissolved in 4 per cent hydrochloric acid, gave strong positive reactions for alkaloids. The separation of the sapwood extracts into the various fractions is summarized in Figure 2, in which the amounts of the products are expressed as percentages by weight of the ether and alcohol extracts respectively.

Extraction of the heartwood with ether gave a rather smaller yield of crystals, melting point 196—205°C. After steeping in ammonia and extraction with ether a dark brown resin was obtained which gave a dark red solution with 4 per cent hydrochloric acid. On making alkaline with ammonia a brown amorphous material was precipitated (0·7 per cent on the weight of wood) which gave strong reactions with alkaloid reagents.

These experiments indicate that one or more alkaloids are present in the wood in addition to the crystalline components investigated by Professor King. It is known that podophyllotoxin has toxic properties, and an attempt is being made to find whether the irritant properties of the wood can be attributed to this substance or to the alkaloid, or perhaps to the resinous components.

Electrochemical Attack on Boat Timbers

A type of breakdown often occurs in the wood of boat hulls, decks, etc., which, although it resembles fungal decay in appearance and in some of its effects, has been shown to be of chemical origin. The form most commonly observed is a localized softening of the wood immediately adjacent to metal fastenings such as the copper clench nails holding double skin hull planks together and the yellow metal bolts which pass right through hull planks, timbers and floors. This softening frequently results in loosening of the fastenings, or "nail sickness", and many instances have been reported where hull planking has had to be renewed very early in the life of wooden craft—particularly in yachts of the small cruising type.

The primary cause of this type of breakdown is thought to be the presence of dissimilar metals in contact with moist wood. The metals form the poles of a galvanic cell, the moisture in the wood forming the electrolyte solution. When the wood contains moisture in which an inorganic salt is dissolved, e.g. sea water, conditions are particularly favourable, and an external connec-

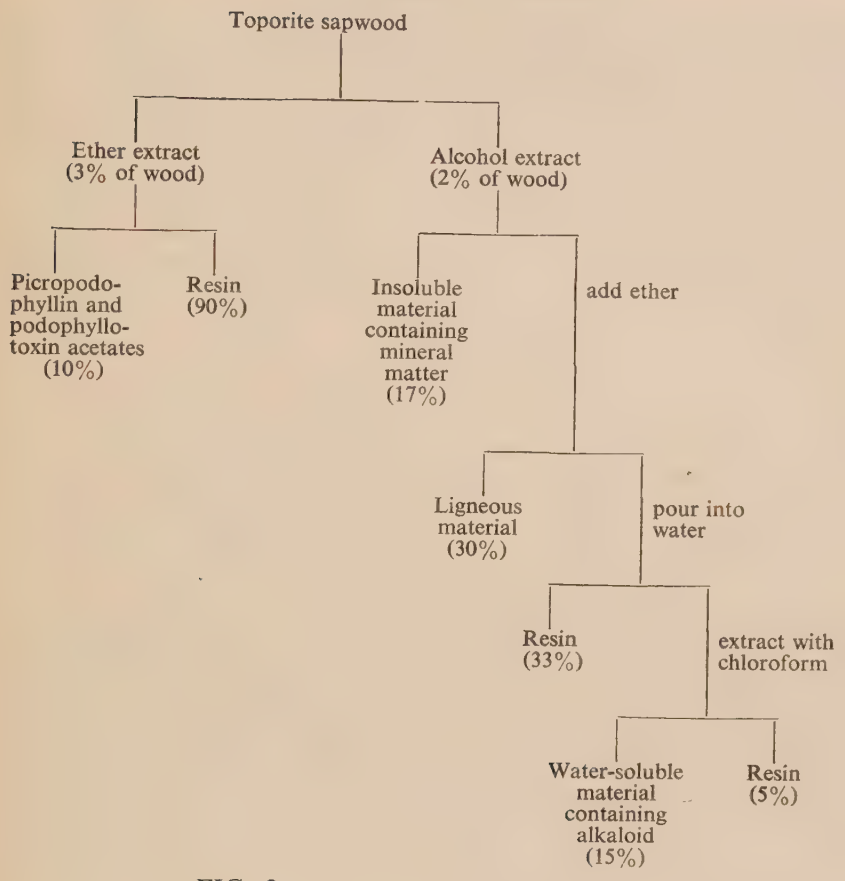


FIG. 2. EXTRACTIVES OF TOPORITE SAPWOOD

tion between the metals can complete the circuit so that the salt in the wood is electrolysed progressively. According to the relative positions of the metals concerned in the electrochemical series, the more " noble " forms the cathode and the less " noble " the anode in the cell. As a result of the electrolysis of the salt, sodium hydroxide forms at the cathode and concentrates in the wood adjacent to it. The chloride ion from the salt combines with the anode of the cell, resulting in corrosion of the latter and formation of new salts around it. When, as is often the case in practice, the anode is iron, secondary reactions ultimately produce free hydrochloric acid which concentrates in the wood around this point.

In order to verify that galvanic action as outlined above does, in fact, take place, simple experiments were set up in which two dissimilar metals were embedded in pieces of wood moistened with salt solution, and connected externally by a wire. It was found that the results resembled very closely those found in boat timbers; alkaline conditions developed rapidly around the cathode and, at least in the case of iron, acid conditions somewhat later at the anode. Anodes of other metals have still to be examined. These experiments were repeated with similar results on several species of both hard and soft woods as well as on blocks of compressed pure cellulose.

Striking practical confirmation of this explanation was obtained in the course of a recent examination of the timbers of the famous "*Cutty Sark*." This vessel which has been afloat for 83 years has teak hull planks of 4—6 in. thickness secured to iron frames and iron diagonal bracing plates by means of massive yellow metal bolts. Numerous localized areas of both strong acidity (hydrochloric acid) and strong alkalinity (sodium hydroxide and sodium carbonate) were found on the inside of the hull above and below the waterline, and very extensive local breakdown of the wood in these regions had occurred. It was possible, at a point slightly above the waterline, to measure a potential difference of 35 to 40 millivolts between an iron plate and a bronze bolt not in direct metallic contact, indicating that electrochemical action through the moisture in the wood was still proceeding.

The softening accompanied by dark colouration of hull planks around copper or yellow metal fastenings in comparatively new vessels is almost invariably due to attack on the wood by caustic soda formed at cathodes. On quite new vessels where this attack has not yet produced any noticeable softening, the presence of alkaline areas is frequently revealed by the destructive effect of caustic soda on stopping compounds and paint or varnish. In many cases investigated, metal bolts giving rise to alkaline areas in external hull planks were found to pass through galvanized iron floors on the inside of the hull. Strongly acidic areas were found in these instances to exist at the surface of timbers in contact with the iron floors. It should be noted that galvanizing, while protecting iron from atmospheric corrosion and the effects of contact with the more acidic woods such as oak, does not prevent it from reacting in the manner described above. The zinc of the coating, being even more anodic to copper than iron, is rapidly attacked at the points of contact with the electrolyte. In the examples quoted rust had formed in quite a short time along the edges of the areas of contact between the iron floors and timber frames.

It is apparent that the part played by the wood in sustaining conditions favourable to galvanic action is merely to act as a reservoir for salt solution. Its moisture content will therefore be of much greater importance than any intrinsic properties inherent in particular species. Observations made by experienced boat builders and surveyors, however, agree in condemning certain species of timber as susceptible to this form of attack and in exonerating certain others. African mahogany in particular has been said to deteriorate rapidly around copper and bronze fastenings under conditions which experience has shown to be innocuous to teak and pitch pine. Opinions on the behaviour of Honduras mahogany are not so unanimous. Examinations have been made therefore of a number of small cruising yachts of similar construction but having hull planking of the following different species :—Honduras mahogany, African mahogany, pitch pine and teak. Although not built to the same design, all these yachts had galvanized iron floors and yellow metal fastenings. Owing to careful maintenance none of the hulls showed advanced softening of the wood. In all cases, however, the planks on the outside immediately adjacent to bolts gave strongly alkaline reactions when tested with moist pH test paper, this showing that galvanic action was proceeding actively in all the hulls irrespective of species.

The difference in behaviour of the various species under approximately similar conditions of use must be attributed to their varying intrinsic resistance to alkali. Some indication of the relative durability of boat-building timbers

exposed to electrochemical action may be deduced from their solubility under standard conditions in alkali. The following data represent the percentage losses in weight of wood raspings after immersion for 24 hours at 15°C in a 5 per cent solution of caustic soda in water, in the ratio of 75 ml. per 1 g of wood.

Species	Loss in weight expressed as percentage of dry weight
Spruce	3·5
Larch	2·7
Pitch pine	6·0
Douglas fir	8·2
Western red cedar	19·0
Teak	7·2
Krabak	6·2
Honduras mahogany	15·6
African mahogany	14·8
Iroko	18·0
Canadian rock elm	10·4
English elm	15·5
English oak	21·5

The order of these results corresponds broadly with the order of resistance found in practice. The softwoods, spruce, larch and pitch pine show uniformly good resistance, together with the hardwood teak. Mahogany, whether African or Honduras variety, is moderate to low and English oak is very low. With a few notable exceptions such as western red cedar, these species would exhibit much the same order of resistance to acid. The long life of the "*Cutty Sark*" is an eloquent tribute to the resistance of teak to attack by both acids and alkalis, though the great thickness of the planking is, of course, also a significant factor.

The ideal precautions which should be taken to prevent damage in boats from these causes would consist in the use of metallic parts of the same or closely related electrode potentials throughout the whole structure, together with efficient means of electrical insulation between the metals themselves and between the metals and wood surfaces. In practice it is seldom possible to avoid entirely the use of dissimilar metals but insulation between them by means of fibre or plastic washers and bushes should be practicable in most instances. Insulation between metal and wood could be provided for in many situations, e.g. the areas of contact between iron floors and timber frames, by the insertion of plastic, rubber, or bitumenised felt gaskets. The more difficult positions would be the areas of contact between shanks of bolts and the wood through which they pass. It is already common practice to coat large bolts, such as keel bolts, as well as the inside walls of the holes which are to receive them, with bitumen, chlorinated rubber paint, etc. It is suggested that an extension of this technique to smaller bolts passing through hull planking or decks, though painstaking, might prove worthwhile.

Where electrical apparatus of any kind is installed in boats particular care should be taken with insulation since very minute stray currents can accelerate the chemical reactions to a marked degree. Reversal of normal galvanic polarity can also occur as a result of stray currents, leading to unexpected results.

A combination of all these measures applied with the attention to detail

which characterises so much of normal boat building practice could not fail to minimise the risk of damage from electrochemical causes even where the least resistant timbers are in use.

Advisory Work in Chemistry

The number of enquiries dealt with by letter in 1952 was 235. In addition, advice was given in a considerable number of instances on chemical aspects of enquiries dealt with by other sections. There appears to be increasing recognition of the importance of chemical factors in determining the suitability of timbers for many purposes.

As in previous years the enquiries have covered a very wide range of subjects. Among those which are perhaps of fairly general interest, and have also involved a considerable amount of experimental work, the following may be mentioned.

Bleaching Wood Flour. One of the major applications of wood flour is in the manufacture of plastics. When pastel-shaded plastics are made it is necessary for the wood flour filler to have a light colour. British wood flour manufacturers are faced with competition from abroad, and while they are able to supply grades suitable for most purposes they have difficulty in producing a "white" wood flour which compares favourably with the Scandinavian product, because the raw material available to them (softwood sawdust) is inferior in colour and cleanliness. The Laboratory was therefore asked to examine the possibility of bleaching the near-white softwood flour, or the sawdust from which it is made, to bring it to a colour acceptable to the plastics manufacturers. Although the improvement in colour that was required was relatively small, examination of the materials showed that the lack of brightness was due to the presence of a small proportion of dark particles rather than to a uniform dull colour. The problem of improving slightly the overall colour was therefore not as simple as it might appear. Experiments with gaseous bleaching agents, which would be relatively simple to apply, failed to give a good permanent colour. Of the liquid bleaching agents hydrogen peroxide made alkaline with sodium silicate gave the best results. A series of experiments has been carried out to find the optimal conditions and to determine the smallest amount of hydrogen peroxide required to give the desired result. The results of the experiments, and an estimate of the cost of the chemicals consumed, have been passed to the wood flour manufacturers for their consideration.

Determination of Arsenic in Wood and Foliage. In connexion with some trials being carried out by the Forestry Commission on the treatment of standing trees with arsenic to facilitate bark removal and to start drying out of the log before felling, information was required on the amount of arsenic present in the timber and foliage of the trees. The arsenic is applied by girdling the trees. It is thought that a part of it may be transported with the sap into the foliage and twigs, whence it might eventually, in the form of litter, have a toxic effect on the young roots of surrounding trees. The arsenic content of wood samples is also of interest in deciding whether there are any hazards in handling such wood and whether arsenic is present in sufficient quantity to reduce insect damage. A procedure was developed for removing the organic matter by digesting the samples with a mixture of sulphuric acid and hydrogen peroxide, the concentrations of which must be controlled within fairly close limits to avoid charring. The resulting clear solution is analysed for arsenic by the Gutzeit

method. The results of these analyses show that both the wood and the needles of Sitka spruce trees subjected to two different treatments contain only very small amounts of arsenic.

PHYSICS

Effect of Temperature on the Elastic Constants of Wood

Using the specially designed humidity oven and the vibration methods for measuring elastic constants, described in previous reports, the effect of temperature on the three principal Young's moduli of beech, oak and Corsican pine has been measured at relative humidities of 30, 60, 80 and 90 per cent.

The results show that at a given humidity, the Young's moduli decrease linearly with increase of temperature, although at 90 per cent relative humidity there is some evidence of a curvilinear relationship. Assuming, however, that the relationship is linear, the effect of temperature can be expressed by the equation.

$$E_T = E_t \{ 1 - a\ (T - t) \},$$

where E_T and E_t are the Young's moduli at temperatures T and t degrees C, T being the higher, and a is the mean temperature coefficient. Values of a for the three species determined over the temperature range 40°—90°C are given in Table 1.

TABLE 1

Values of a

R.H.%	30	60	80	90
(1) Longitudinal Specimens				
Beech	0·0014	0·0017	0·0023	0·0038
Oak	0·0013	0·0017	0·0021	0·0038
Corsican pine	0·0012	0·0015	0·0020	0·0034
(2) Radial Specimens				
Beech	0·0024	0·0034	0·0048	0·0091
Oak	0·0025	0·0038	0·0054	0·0106
Corsican pine	0·0023	0·0037	0·0050	0·0076
(3) Tangential Specimens				
Beech	0·0023	0·0038	0·0048	0·0091
Oak	0·0029	0·0046	0·0063	0·0125
Corsican pine	0·0033	0·0037	0·0047	0·0072

The temperature coefficients do not vary greatly from one species to another, or from the radial to the tangential specimens, but the longitudinal modulus is only about half as sensitive to temperature change as the transverse moduli.

During the experiments, small specimens of the three species concerned were suspended on quartz springs inside the oven, and, by measuring the lengths of the springs, the moisture contents of the specimens were estimated.

These moisture contents proved surprisingly low; their approximate values at 30°C are given and compared with approximate normal values in Table 2.

TABLE 2

R.H.%	Moisture Contents Per Cent		
	Test Specimens	Normal	
		Adsorption	Desorption
30	5	6	8
60	8	11	13
80	11	16	19
90	13	20	24

The reduction in subsequent equilibrium moisture content after heating wood in a dry atmosphere is well known, but the figures in Table 2 show that this reduction also occurs on heating in a moist atmosphere. Evidently the heating introduces irreversible changes in the wood, but the present experiments support the view that after heating for 1 or 2 days, there is no further change. The temperature coefficients in Table 1 therefore refer to wood which has been "conditioned" by heating.

Wood-water Relations

Measurements of the effect of temperature on the vapour pressure isothermal of wood have been continued, and isothermals at 25° and 30°C completed. This work has been carried out by the standard method of measuring simultaneously the vapour pressure and moisture content at equilibrium. This method, however, becomes very difficult and inaccurate at high relative humidities, and in practice, wood exposed to a saturated atmosphere will not absorb more than about 30 per cent of water. By saturating wood with water, however, considerably higher moisture contents can be attained, and some attention has been given to possible methods of exploring the region above about 30 per cent moisture content.

Three methods which have been found useful in studying soil-water relations are the measurement of (1) the freezing point depression, (2) the amount of water held against a direct suction applied to the material, (3) the amount of water held in a centrifugal field. Special difficulties arise with each of these methods when attempts are made to apply them to wood. The experiments carried out so far however show that application of suction reduces the moisture content of saturated wood to a steady value in the course of a few days. Preparations are now being made to study the suction-moisture content relation of wood in more detail. Attempts are also being made to condition wood samples to a moisture content suitable for measuring the freezing point depression. Centrifuge experiments, which would also be of interest in connexion with recent suggestions for seasoning wood by the application of centrifugal force, await the availability of suitable apparatus.

Diffusion of Water Vapour through Wood. The experiments on the flow of water vapour through discs of wood at various temperatures under a relative humidity gradient of 100 per cent have now been completed. The flow through 12 species in the three principal directions was investigated, and the results,

when reduced to a comparable basis, show that with one exception the magnitude of flow through all species and at all temperatures is greatest in the longitudinal direction and least in the tangential direction. The exception is Sitka spruce, for which the radial flow is slightly less than the tangential flow. In other species the radial flow is 2-4 times the tangential flow, and in all species the longitudinal flow is about 10-25 times the tangential flow. Temperature has a marked effect on the absolute magnitude of flow, which is approximately doubled in all directions on raising the temperature from 20°-40°C. This, of course, is due mainly to the rise in vapour pressure from 20°-40°C.

Dielectric Properties of Wood

The results of the measurements of dielectric properties of a number of species as affected by moisture content and frequency have been further analysed. It appears that the dielectric constant at all frequencies and moisture contents can be estimated from the equation

$$k = 1 + cd,$$

where k is the dielectric constant, d is the density, and c is a factor which can be determined empirically from curves which have been prepared giving c as a function of moisture content and frequency. A fuller report on these measurements is being prepared.

Physics—Miscellaneous Investigations

(a) The presence of insects in timber can be detected by X-rays. The possibility of using gamma rays from radio-active isotopes for this purpose has been investigated, but it appears that at present there is no suitable isotope available.

(b) The specific heat of wood at various moisture contents is usually calculated by a simple mixture law from the specific heats of dry wood and water, and the proportions of the two components, but it seems that no experiments have ever been made to check this calculation. Some preliminary tests have therefore been made to discover a suitable method of measuring the specific heat of wood at various moisture contents.

(c) The values available in the literature for the vapour pressures of saturated lithium chloride solutions at various temperatures have been assembled and compared among themselves. If these vapour pressures were known with sufficient accuracy, then a new and ingenious method of measuring relative humidity, known commercially as the " dew cell," would yield absolute values. The discrepancies among the results of different workers, however, suggest that at present the method, although giving rough absolute values, is not capable of high precision without individual calibration.

(d) In the classical theory of elasticity, it is assumed that the strains are small and are directly proportional to the applied stress. If these assumptions are rejected, a number of interesting results follow, one, in particular, being that the elastic constant of a material should depend on the applied hydrostatic pressure. The theory of this effect has not yet been developed sufficiently for it to be used for wood, nor are any experimental results available. However, the theory has been fully developed for materials possessing cubic symmetry, and an analysis has been made of some recently published results for the effect of hydrostatic pressure on the elastic constants of certain cubic materials. It appears that the results can be interpreted satisfactorily in terms of the available theory.

Advisory Work in Physics

Outside enquiries relating to the following properties and applications of physics to wood problems have been answered: thermal conductivity; calorific value; electrical properties; sinking of logs; effect of temperature on physical properties; and detection of metal. In addition, two lists of references, dealing with the hygroscopicity of wood and with the theory of the drying process, have been compiled in response to enquiries.

EXTERNAL RELATIONS

Timbers for Testing

Few new species have been brought in during the year owing to the heavy accumulation of timbers already undergoing general tests. Progress, however, has been excellent and, of the twenty-three species still being tested at the beginning of the year, only ten species remain unfinished. Thirteen reports were printed and distributed, covering the following timbers: agba, *Brachystegia* and *Isoberlinia*, danta, makoré, ramin, dahoma, berlinia, idigbo, nyankom, pterygota, utile, yellow sterculia, Japanese larch (home-grown).

Timbers procured for testing were as follows:
for general tests: kurokai (British Guiana); wamara (British Guiana); Sitka spruce (Inverliever); Sitka spruce (Gravetye, Kent);
for special tests: pachylobus (Gold Coast); sapele (Commercial); crabwood (British Guiana); mahogany (Commercial); sycamore (Forest of Dean); meranti (Kuala Lumpur); kempas (Kuala Lumpur); keruing (Kuala Lumpur); balau (Kuala Lumpur); yellow birch (Commercial); gaboon (Commercial).

In addition, small parcels of home-grown oak, beech, ash, Scots pine, spruce, poplar and birch were procured for various experiments.

The Utilization Officer in Uganda made strength tests on two Uganda timbers, *Albizzia grandibracteata* and *Chrysophyllum albidum*, during a 'refresher' visit. A third Uganda species, *Celtis soyauxii*, arrived in very bad condition and it was decided that no useful results could be obtained from the tests. A Trinidad timber, *Cedrela mexicana*, was similarly tested by an officer of the Trinidad Forest Department on visit.

The Handbook of Empire Timbers

Revision of the Handbook of Empire Timbers was begun in the latter part of the summer. As the book has been supplemented but not revised since 1945, and as much new information is available and new timbers have been tested which are not in it, the work has been given priority. It will take about a year to complete the hardwood section of the book as there will be approximately 170 species involved.

Timber Quality in Relation to Sylviculture

Co-operation has continued between the Forestry Commission and the Laboratory in studying the quality of timber of the thinnings from young plantations in relation to site and soil.

The first consignment of Japanese larch from Stourton, Wiltshire, was fully tested through all sections except CompositeWood and a report[1] was published

[1] Properties and Thinnings of Home-Grown Japanese Larch (Larix Leptolepis), Progress Report I. Consignment 733. (F.P.R.L. Neostyled Report 1952).

towards the end of the year. Taking into account that the logs tested came from trees taken out in normal sylvicultural thinning which would not produce the best logs in the stand, the timber on the whole gave very satisfactory results and showed good promise for the future crop.

A feature that was very noticeable was the desirability of pruning the species at an early age and of ensuring that the branches were pruned tight to the trunk of the tree. Dead snags or branches are very persistent and become encased in resin, causing a large number of loose knots. When such knots do not become loose they chip badly when sawn or worked with a cutter edge.

The timber when sawn was graded. The butt logs gave 6·8 per cent of grade I lumber, 62·8 per cent of grade II and 30·4 per cent of grade III. The second length logs gave no grade I, which was to be expected, but 54·1 per cent of grade II and 45·9 per cent of grade III. Considering that the average size of the 20-foot butt logs taken over bark was 9·06 cu. ft. Hoppus measure and the second length 6·20 cu. ft. Hoppus measure, the outturn was very good.

This was the first time that the grading rules drawn up in the Laboratory had been put to a practical test and they worked well. So far no points have come to light which would require alteration of the original tables but more information will be gained as to their suitability as other species are graded and tested.

During the year two separate consignments of Sitka spruce thinnings were received. The first came from Inverliever Forest, Scotland, grown on clay, with a rainfall of 80-90 in. per annum and at an elevation of 345 ft. above sea level. The second came from Gravetye, Kent, and was grown on sandy clay with a rainfall of 25-30 in. per annum. Tests on these two consignments have been started and should be completed within the next twelve months.

Surveys of Main Timber-using Industries

Visits to timber merchants and factories have been limited by the amount of work to be done within the Laboratory. Among the workshops and yards inspected were those of furniture makers, brush makers, import timber merchants, joinery manufacturers and bus and coach builders.

Visitors

During the year the maximum number of visitors that could be handled was dealt with. In addition to the usual flow of technical visitors coming to the sections for specialized information, visitors from 27 nations or colonies came to the Laboratory. Their countries of origin illustrate the breadth of the Laboratory's connexions:—Australia, Austria, Burma, Ceylon, Dutch Guiana, France, Finland, Germany, Gold Coast, India, Japan, Kenya, New Zealand, Nigeria, Norway, Pakistan, Paraquay, Persia, Sarawak, Siam, Southern Rhodesia, Switzerland, Tanganyika, Trinidad, Uganda, Union of South Africa, and Yugoslavia. It is satisfactory to note that many of these overseas visitors were foresters and timber merchants. One of the visitors from Trinidad was The Hon. Mr. Victor Bryan, Minister of Agriculture of Trindad and Tobago, under whose charge are the forestry department and the timber-working industries. The visitors from Norway and Siam came to inspect the organization of the Laboratory's work in connexion with proposed laboratories in their respective countries.

Education

A heavy programme was carried out during the year. The usual courses for forestry students from the Universities of Oxford (41 students), Aberdeen (20 students) and Bangor (15 students) were given. The Oxford post-graduate course included many men from the Forestry Departments of the Commonwealth and Empire. Eleven special courses for individual students were arranged, including two of a year's duration.

The Ministry of Works and British Railways sent members of their staffs for short instructional visits. Twenty botany students from London University, and 225 from technical colleges and other educational institutes made one-day visits. Owing to shortage of staff and time, however, many other applications from technical schools had to be refused.

Six of the regular courses for kiln operators have been held during the year, and these were attended by 59 trainees. Three trainees have received special instruction in wood bending.

Lectures and Exhibitions

The demand on our specialist officers for lectures has been very great. As most of the requests come from technical societies whose members are engaged in industry and therefore form very receptive audiences, everything has been done to provide lecturers without undue loss of staff time. Almost all senior officers have given one or more such technical lectures during the year.

At the Furniture Exhibition at Earl's Court in February, the Laboratory demonstrated the latest developments in wood bending and showed the wood-bending film continuously on the stand. Many of the newer Colonial timbers were on view, including those of interest to furniture manufacturers, as well as many of those mentioned in the Laboratory's publication " Hardwoods for Building and General Purposes."

The travelling exhibition on dry rot and woodworm, after having been shown in towns all over the country for some $2\frac{1}{2}$ years, completed its tour at the beginning of the year and was finally shown during May at the Building Centre in London.

During the year the customary material, exhibits and advice have been given for various shows and exhibitions.

Advisory and Liaison Work

The technical enquiries dealt with during the year by the External Relations Section were 205.

F. Y. HENDERSON,
Director.

FOREST PRODUCTS RESEARCH LABORATORY,
Princes Risborough,
Aylesbury, Bucks.

February, 1953.

APPENDIX I

STAFF AT THE FOREST PRODUCTS RESEARCH LABORATORY

31st December, 1952

Director of Forest Products Research: F. Y. Henderson, C.B.E., D.Sc., D.I.C.

ADMINISTRATION

Assistant Director: S. T. C. Stillwell, O.B.E., B.Sc.
Senior Principal Scientific Officers: J. Bryan, M.Eng., A.M.Inst.C.E.; K. T. St.G. Cartwright, M.A., D.I.C.
Higher Executive Officer: R. D. Weeks.
Executive Officer: Miss D. Lacey.

SECTION OF WOOD STRUCTURE

Principal Scientific Officers: B. J. Rendle, B.Sc., A.R.C.S. (Officer in Charge); E. W. J. Phillips, B.Sc., Ph.D., A.R.C.S.
Scientific Officer: J. D. Brazier, B.Sc.
Experimental Officer: G. L. Franklin.
Temporary Assistant Experimental Officer: Miss L. M. Holtham.

SECTION OF PHYSICS

Principal Scientific Officer: R. F. S. Hearmon, A.Inst.P. (Officer in Charge).
Experimental Officers: J. N. Burcham; J. McC. Paton.
Assistant Experimental Officer: E. H. Adams.

SECTION OF SEASONING

Principal Scientific Officer: W. C. Stevens, M.A., A.M.I.Mech.E. (Officer in Charge).
Senior Experimental Officers: R. E. Hodge, A.I.Mech.E.; D. D. Johnston; G. H. Pratt; N. Turner.
Experimental Officer: A. R. Dean.
Temporary Assistant Experimental Officer: T. R. Suckling.

SECTION OF TIMBER MECHANICS

Senior Principal Scientific Officer: J. Bryan, M.Eng., A.M.Inst.C.E. (Officer in Charge).
Principal Scientific Officers: F. H. Armstrong, M.Sc., A.M.I.Mech.E.; J. Latham, B.Sc.
Scientific Officer: A. J. Comben, B.Sc.
Senior Experimental Officer: A. J. Foord.
Experimental Officer: J. G. Sunley, B.Sc.
Assistant Experimental Officers: G. R. Brock; W. T. Curry; Miss W. M. Fogerty.

SECTION OF WOOD PRESERVATION

Principal Scientific Officer: N. A. Richardson, B.Sc., A.R.I.C. (Officer in Charge).
Senior Experimental Officer: D. N. Smith.
Experimental Officer: L. W. Redding.
Assistant Experimental Officers: R. Cockcroft; Miss E. Lee; D. F. Purslow.

SECTION OF CHEMISTRY

Principal Scientific Officer: R. H. Farmer, B.A., B.Sc., D.Sc.(Tech.), F.R.I.C. (Officer in Charge).
Senior Scientific Officer: R. A. Laidlaw, B.Sc., Ph.D.
Scientific Officer: Mrs. W. R. Carruthers, B.Sc.
Experimental Officers: D. F. Packman; L. C. Pinion, B.Sc.

SECTION OF MYCOLOGY

Senior Principal Scientific Officer: W. P. K. Findlay, D.Sc., A.R.C.S., D.I.C., A.I.C.T.A. (Officer in Charge).
Senior Scientific Officer: J. G. Savory, B.Sc.
Experimental Officer: E. C. Badcock.
Assistant Experimental Officer: Miss C. A. Clements, B.Sc.

SECTION OF ENTOMOLOGY

Principal Scientific Officer: R. C. Fisher, B.Sc., Ph.D., F.R.S.E. (Officer in Charge).
Senior Scientific Officer: J. D. Bletchly, B.A., B.Sc., F.R.E.S.
Temporary Scientific Officer: M. G. White, B.A.
Senior Experimental Officer: E. C. Harris.
Assistant Experimental Officer: Miss J. M. Taylor, B.Sc.

SECTION OF WOODWORKING

Principal Scientific Officer: P. Harris, B.Sc., A.M.I.Mech.E. (Officer in Charge).
Senior Experimental Officer: R. Goodchild.
Experimental Officer: H. J. Endersby.

SECTION OF EXTERNAL RELATIONS

Principal Scientific Officer: F. G. O. Pearson, B.Sc. (Officer in Charge).
Assistant Experimental Officers: Miss M. E. Smart, B.Sc.; Miss C. Webster.

SECTION OF COMPOSITE WOOD

Principal Scientific Officer: R. A. G. Knight, B.Sc.(Eng.), M.I.Mech.E. (Officer in Charge).
Scientific Officers: J. F. S. Carruthers, B.Sc.; T. P. Hughes, B.Sc.
Senior Experimental Officers: L. S. Doman; R. J. Newall.
Assistant Experimental Officer: P. Burgess, B.Sc.

SECTION OF PUBLICATIONS AND RECORDS

Senior Experimental Officer: C. J. N. McCracken, B.A., Dip.For. (Officer in Charge).
Experimental Officer: C. L. Stocker, B.A., Dip.For.
Assistant Experimental Officer: Miss E. M. M. Wood.

DRAWING OFFICE AND PHOTOGRAPHY

Senior Photographer: W. J. Baldwin.
Experimental Officer: E. A. Steel, A.I.Mech.E.

APPENDIX II

LIST OF PUBLICATIONS ISSUED DURING 1952

A. Stationery Office Publications

Forest Products Research 1950.
Forest Products Research 1951.
Kiln Operator's Handbook. By W. C. Stevens, M.A., A.M.I.Mech.E., and G. H. Pratt.

Bulletins:
No. 1. Dry Rot in Wood. (*Fifth edition*). By K. St.G. Cartwright, M.A., D.I.C. and W. P. K. Findlay, D.Sc., D.I.C.
No. 25. Identification of Hardwoods. A Lens Key.

B. Other Publications

Leaflets:*
No. 13. The Kiln Sterilization of *Lyctus*-infested Timber. (*Revised edition*).
No. 14. The House Longhorn Beetle. (*Revised edition*).
No. 42. Kiln-drying Schedules. (*Revised edition*).

*Timber Leaflets**
Agba—*Gossweilerodendron balsamiferum.*
Berlinia—*Berlinia* spp., principally *B. acuminata.*
Brachystegia spp., probably *B. boehmii* and *B. spiciformis*, and *Isoberlinia*, probably *I. globiflora.*
Dahoma—*Piptadenia africana.*
Danta—*Cistanthera papaverifera.*
Idigbo—*Terminalia ivorensis.*
Makoré—*Mimusops heckelii.*
Nyankom—*Tarrietia utilis.*
Pterygota—*Pterygota kamerunensis* and *P. macrocarpa.*
Ramin—*Gonystylus* sp.
Utile—*Entandrophragma utile.*
Yellow sterculia—*Sterculia oblonga.*

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